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Characteristics of Urban Transportation Systems

Revised Edition
September 1992

FEDERAL TRANSIT ADMINISTRATION

Characteristics of Urban Transportation Systems

Revised Edition
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CHAPTER 1

INTRODUCTION

Good decisions about transportation investments and policies require accurate information on characteristics of transportation system alternatives. The literature offers many tools for estimating these characteristics; however, the data presented are often out-of-date, inconclusive, unspecified, or highly local in nature. The very number of sources can confuse rather than help in the search for pertinent information, and measurement differences can result in statistics being misleadingly compared or grouped.

The objective of this document is to provide a single source of sketch planning data on the most important performance characteristics of contemporary urban transportation systems in a format that lends itself to easy reference. This handbook does not deal explicitly with passenger demand, but assesses only the supply or performance characteristic of urban transportation systems, including the following:

- Speed
- Capacity
- Operating costs
- Labor inputs
- Capital costs
- Energy consumption
- Emission of air pollutants
- Accident rates and costs

Organization of This Handbook

The substantive material in this handbook is organized into five chapters:

- Rail Transit (rapid, light, and commuter)
- Bus Transit
- Automobiles, Trucks, and the Highway System

- High-Occupancy Vehicle (HOV) Lanes
- Automated Guideway Transit (AGT)

Each chapter consists of a brief introduction and a series of tables providing quantitative information on system characteristics. To the extent possible, tables in this handbook are designed to stand alone, with sources and definitions repeated on individual tables.

Caveats Regarding Use of This Handbook

This handbook is specifically for use by transportation planners in the preliminary evaluation of alternative systems, and so the relationships presented are purposely simplified. In most cases, these relationships are not sufficiently refined for use in detailed studies such as transit operations analysis, traffic engineering, or detailed design. Nothing in this handbook should be used to supersede or confute competently developed site-specific estimates.

Obviously, dollar values presented in this handbook will need to be adjusted for inflation as time passes. Consumer, transportation, labor, and construction cost price indices are presented in Appendix A.

How To Acquire Additional or Updated Information

This section provides a brief description of key annual and monthly statistical sources that can be used to update the information in this handbook.

Survey of Current Business, published monthly by the Bureau of Economic analysis of the U.S. Department of Commerce, is a comprehensive source of price and income data. It contains many detailed cost indices, as well as other information on economic activity. Orders should be sent to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Phone: (202)-783-3238.

Recorded information on price indices and other economic indicators compiled by the Bureau of Labor Statistics (BLS) is available on the following numbers:

- Major BLS Indicators -- (202)-523-9658
- Consumer Price Index detail -- (202)-523-1239
- Producer Price Index detail -- (202)-523-1765

Economic Indicators, published monthly by the Joint Economic Committee of the U.S. Congress, summarizes general price indices and other economic indicators. Orders should be sent to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Phone: (202)-783-3238.

Engineering News-Record, published weekly by McGraw Hill, Inc., contains information on construction and construction prices. Subscription orders should be sent to Fulfillment Manager, Engineering News-Record, P.O. Box 430, Hightstown, NJ 08520.

National Urban Mass Transportation Statistics, published annually by the Federal Transit Administration, contains information about each transit operation in the U.S. that receives FTA support. It includes data on transit revenues, expenses, services, safety, energy consumption, maintenance, mileage, employee counts, fleet size, and fleet age. The document is available from the Office of Technical Assistance, Federal Transit Administration, 400 7th Street, S.W., Washington, D.C. 20590. Phone: (202)-426-9157.

Transit Fact Book, published annually by the American Public Transit Association (APTA), provides a statistical profile of U.S. transit and trends of transit finances and operations. This document is available from American Public Transit Association, 1201 New York Avenue, N.W., Suite 400, Washington, D.C. 20005. Phone: (202)-898-4000.

Motor Vehicle Facts and Figures, published annually by the Motor Vehicle Manufacturers Association, gives price, production, operating cost, fleet composition, accidents, and fuel economy data assembled from various primary sources. Copies can be ordered from the Communications Department, Motor Vehicle Manufacturers Association, 300 New Center Building, Detroit, Michigan 48202.

Statistical Abstract of the United States, published annually by the U.S. Bureau of the Census, contains a wealth of price, income, production, and other data of interest to transportation planners. The Statistical Abstract can be ordered from the superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Phone: (202)-783-3238.

Highway Statistics, published annually by the Federal Highway Administration, contains data on motor fuel consumption, motor vehicle registration, drivers licenses, highway finance, highway travel, fuel economy, and highway performance. *Highway Statistics* is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Phone: (202)-783-3238.

CPI Detailed Report, published monthly by the Bureau of Labor Statistics, reports monthly consumer price movements (including gasoline prices) in urban areas. Single copies or subscriptions can be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Phone: (202)-783-3238.

Monthly Labor Review, published monthly by the Bureau of Labor Statistics, provides articles on labor force, wages, prices, productivity, and economic growth. Each issue presents an up-to-date review of the principal statistical series collected by the BLS, including data on employment, unemployment, consumer and producer prices, wages, and productivity. Single copies or subscriptions can be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Phone: (202)-783-3238.

CHAPTER 2

RAIL TRANSIT

This chapter provides quantitative information on the following characteristics of rapid rail, light rail, and commuter rail systems:

- Speeds
- Accident rates
- Operating costs
- Labor requirements
- Energy consumption
- Capital costs
- Capacities

Information on speeds, accident rates, operating costs, labor requirements, and energy consumption in this chapter are summarized (in the form of average, high, and low values) from 1989 UMTA Section 15 reports. Data on the characteristics of individual rail systems are presented in Appendix B.

TABLE 2-1

AVERAGE RAIL TRANSIT SPEEDS

	Systemwide Speed (MPH)[1]		
	Low[2]	Average[3]	High[2]
Rapid Rail (12)[4]	15.8	22.5	29.0
Light Rail (12)	8.9	12.0	23.3
Commuter Rail (9)	27.6	30.1	36.5

SOURCE: UMTA Section 15 data for 1989

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[1]Systemwide speed is actual vehicle revenue miles per vehicle revenue hour of operation. Revenue miles exclude all vehicle miles traveled when not in regular passenger service (i.e., deadheading). The ratio of total vehicle miles to revenue miles is shown in Tables B-1, B-2, and B-3 in Appendix B for each rail rapid transit system, light rail system, and commuter rail system, respectively. The ratios average 1.04, 1.02, and 1.08 for the three rail modes.

[2]Low and high values omit two small systems that may be unrepresentative: Seattle's two car streetcar operation (5.0 mph) and Staten Island Rapid Transit, a 36 car system which is classified as commuter rail (21.2 mph).

[3]Average speeds are harmonic means, unweighted by system size. Harmonic means are calculated by (1) inverting speeds for each system to get hours per mile, (2) taking the arithmetic mean of hours per mile, and (3) inverting the result. For example, the harmonic mean of 50 mph and 25 mph is calculated by (1) inverting the two speeds to get 0.02 and 0.04 hours per mile respectively, (2) taking the arithmetic mean to get 0.03 hours per mile, and (3) inverting the result to get 33.3 mph.

[4]Number of systems used in calculating averages.

TABLE 2-2

RAIL TRANSIT ACCIDENTS PER MILLION PASSENGER MILES

	Accidents	Injuries	Deaths
Rapid Rail			
Average (12)[1]	0.98	0.91	0.003
Low	0.21	0.21	0.000
High	2.91	2.21	0.017
Light Rail			
Average (13)	6.43	3.93	0.020
Low	0.08	0.00	0.000
High	15.37	7.91	0.151
Commuter Rail			
Average (10)	0.59	0.52	0.007
Low	0.00	0.00	0.000
High	2.38	1.83	0.029

SOURCE: UMTA Section 15 data for 1989

[1]Number of systems used in calculating averages.

TABLE 2-3

RAIL TRANSIT OPERATING COSTS

	Cost Per Revenue Vehicle Mile	Cost Per Revenue Vehicle Hour	Cost Per Place Mile[1]	Cost Per Passenger Mile
Rapid Rail				
Average (12)[2]	$6.53	$152	$0.0492	$0.282
Low	3.31	56	0.0163	0.135
High	10.33	272	0.0876	0.419
Light Rail				
Average (13)	9.31	125	0.0960	0.578
Low	3.33	30	0.0180	0.201
High	18.61	262	0.1578	1.504
Commuter Rail				
Average (10)	9.96	307	0.0687	0.261
Low	5.93	178	0.0469	0.127
High	23.39	724	0.1519	0.438

SOURCE: UMTA Section 15 data for 1989

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[1]Place miles (or revenue capacity miles) are calculated as revenue vehicle miles times the average passenger capacity (seated plus standing) of the active vehicles in the fleet.

[2]Number of systems used in calculating averages.

TABLE 2-4

DISTRIBUTION OF RAIL TRANSIT OPERATING COSTS BY OBJECT CLASS

	Rapid Rail[1] (12 systems)	Light Rail[1] (13 systems)	Commuter Rail[1] (10 systems)
Operator Salaries and Wages	9.3%	18.1%	11.0%
Other Salaries and Wages	40.7	34.5	29.6
Fringe Benefits	29.2	26.2	28.6
Utilities	8.7	9.4	6.1
All Other Costs	12.1	11.7	24.7
Total	100.0%	100.0%	100.0%

SOURCE: UMTA Section 15 data for 1989

[1]Percentages are calculated from average costs in each category for all systems reporting.

TABLE 2-5

RAIL TRANSIT EMPLOYEES PER THOUSAND REVENUE VEHICLE MILES

	Transportation	Maintenance	Administration	All Employees
Rapid Rail				
Average (12)[1]	32.4	49.6	21.2	103.1
Low	14.6	25.4	5.7	80.7
High	53.5	89.2	35.4	178.0
Light Rail				
Average (12)	70.5	98.8	23.5	192.8
Low	26.8	28.5	4.2	62.5
High	107.2	142.8	41.2	278.4
Commuter Rail				
Average (10)	48.8	57.4	15.3	121.6
Low	27.0	24.5	1.3	74.0
High	72.8	77.9	33.8	175.2

SOURCE: UMTA Section 15 data for 1989

[1]Number of systems used in calculating averages.

TABLE 2-6

RAIL TRANSIT EMPLOYEES PER THOUSAND REVENUE VEHICLE HOURS

	Transportation	Maintenance	Administration	All Employees
Rapid Rail				
Average (12)[1]	734	1,141	492	2,366
Low	372	605	135	1,583
High	1,412	2,353	932	4,697
Light Rail				
Average (12)	887	1,222	312	2,421
Low	499	538	38	1,179
High	1,392	2,17[illegible]	885	4,450
Commuter Rail				
Average (10)	1,480	1,748	465	3,694
Low	806	755	21	2,276
High	2,362	2,636	1,234	5,428

SOURCE: UMTA Section 15 data for 1989

[1]Number of systems used in calculating averages.

TABLE 2-7

RAIL TRANSIT EMPLOYEES PER VEHICLE OPERATED IN MAXIMUM SERVICE

	Transportation	Maintenance	Administration	All Employees
Rapid Rail				
Average (12)[1]	1.98	2.95	1.27	6.20
Low	0.85	1.74	0.34	3.67
High	3.76	4.97	1.97	9.93
Light Rail				
Average (12)	2.36	3.10	0.75	6.21
Low	1.14	1.30	0.10	2.68
High	3.58	4.46	1.38	9.30
Commuter Rail				
Average (10)	2.12	2.52	0.69	5.33
Low	0.96	1.17	0.04	2.42
High	3.47	4.28	1.78	9.11

SOURCE: UMTA Section 15 data for 1989

[1]Number of systems used in calculating averages.

TABLE 2-8

RAIL RAPID TRANSIT ENERGY CONSUMPTION

	Kilowatt Hours			
	Per Revenue Vehicle Mile	Per Revenue Vehicle Hour	Per Thousand Place Miles[1]	Per Thousand Passenger Miles
Average (12)[2]	7.63	179	60.6	323
Low	5.04	110	24.8	205
High	14.35	378	116	482

SOURCE: UMTA Section 15 data for 1989

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[1]Place miles (or revenue capacity miles) are calculated as revenue vehicle miles times the average passenger capacity (seated plus standing) of the active vehicles in the fleet.

[2]Number of systems used in calculating averages.

TABLE 2-9

LIGHT RAIL TRANSIT ENERGY CONSUMPTION

	Kilowatt Hours			
	Per Revenue Vehicle Mile	Per Revenue Vehicle Hour	Per Thousand Place Miles[1]	Per Thousand Passenger Miles
Average (13)[2]	11.09	161	99.6	542
Low	3.89	35	22.3	149
High	41.85	626	377	1,723

SOURCE: UMTA Section 15 data for 1989

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[1]Place miles (or revenue capacity miles) are calculated as revenue vehicle miles times the average passenger capacity (seated plus standing) of the active vehicles in the fleet.

[2]Number of systems used in calculating averages.

TABLE 2-10

COMMUTER RAIL ENERGY CONSUMPTION

	Kilowatt Hours[1]			
	Per Revenue Vehicle Mile	Per Revenue Vehicle Hour	Per Thousand Place Miles	Per Thousand Passenger Miles
Average	12.68	321	76.6	480
Low	9.00	191	51.4	438
High	16.37	451	101.7	522

(continued)

SOURCE: UMTA Section 15 data for 1989

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[1]Averages, lows, and highs are for the two systems that consume only electric power -- Staten Island and SEPTA. Four systems consume both electric and diesel power -- New York-LIRR, Newark-NJT, Chicago-Commuter Rail Board, and New York-MTNR.

[2]Place miles (or revenue capacity miles) are calculated as revenue vehicle miles times the average passenger capacity (seated plus standing) of the active vehicles in the fleet.

TABLE 2-10 (continued)

	Diesel and Other Liquid Petroleum Fuel (Gallons)[3]			
	Per Revenue Vehicle Mile	Per Revenue Vehicle Hour	Per Thousand Place Miles	Per Thousand Passenger Miles
Average	0.808	26.5	5.68	18.0
Low	0.57	17.4	4.80	13.7
High	0.99	32.1	6.80	22.6

[3]Averages, lows, and highs are for the four systems that consume only diesel power -- Boston, SF Caltrans, Chicago & NW, and Chicago-Burlington Northern.

TABLE 2-11
CAPITAL COSTS OF RECENTLY CONSTRUCTED RAIL RAPID TRANSIT SYSTEMS
(1988 DOLLARS)

Location	Line-Miles	Percent Underground	Stations	Capital Cost (millions)	Cost Per Line-Mile (millions)
Atlanta	26.8	42%	26	$2,720	$101.49
Baltimore	7.6	56	9	1,289	169.61
Miami	21.0	0	20	1,341	63.86
Washington	60.5	57	57	7,968	131.70

Source: Don Pickrell; Urban Rail Transit Projects: Forecast Versus Actual Ridership and Costs; prepared for Office of Grants Management, Urban Mass Transportation Administration; October, 1989.

TABLE 2-12
DISTRIBUTION OF RAIL RAPID TRANSIT CAPITAL COSTS BY SUBSYSTEM
(PERCENT)

Subsystem	San Francisco BART All	Atlanta MARTA Phase A	Baltimore MTA Phase I	Chicago CTA O'Hare	Boston MBTA Red Line South
Land	7%	9%	2%	0%	11%
Guideway	37	33	25	20	15
Stations	19	20	30	28	33
Trackwork	3	2	2	7	7
Power	2	1	2	5	6
Control	4	2	4	8	7
Facilities	2	3	2	4	0
Eng./Mgt./Test	14	23	24	8	6
Vehicles	12	7	9	20	15
Total	100%	100%	100%	100%	100%

Source: Thomas Dooley; Transportation Systems Center, U.S. DOT; 1982.

TABLE 2-13
CAPITAL COSTS FOR RECENTLY CONSTRUCTED LIGHT RAIL SYSTEMS
(MILLIONS OF 1990 NATIONAL[1] DOLLARS)

Cost Category	Portland	Sacramento	San Jose	Pittsburgh	Los Angeles
Guideway Elements	$106.6	$47.9	$56.1	$124.0	$135.1
Yards and Shops	13.4	4.1	18.9	42.8	40.2
Systems	23.8	20.0	26.5	66.1	104.7
Stations	16.9	10.5	4.0	38.5	59.9
Vehicles	33.2	34.9	51.7	64.4	72.6
Special Conditions[2]	6.5	12.5	7.5	11.3	150.7
Right of Way	17.0	17.9	49.4	24.8	54.6
Soft Costs[3]	65.1	40.2	120.8	252.2	208.4
Total	282.5	188.1	334.8	624.1	826.2

[1]Actual construction costs were converted to 1990 National Dollars using *Means Construction Cost Indices* by city and year. National costs represent the average for 30 major cities.

[2]Most of the costs in the "Special Conditions" category are for utility relocations. Other costs in this category include demolitions, roadway changes, and environmental treatments.

[3]Soft Costs include feasibility studies, engineering and design studies, project management, project initiation (insurance, mobilization, maintenance of traffic), finance charges, training, and testing.

TABLE 2-14
PERCENTAGE DISTRIBUTION OF LIGHT RAIL CAPITAL COSTS BY COST CATEGORY

Cost Category	Portland	Sacramento	San Jose	Pittsburgh	Los Angeles	Average
Guideway Elements	37.7%	25.5%	16.8%	19.9%	16.4%	23.2%
Yards and Shops	4.7	2.2	5.6	6.9	4.9	4.9
Systems	8.4	10.7	7.9	10.6	12.7	10.1
Stations	6.0	5.6	1.2	6.2	7.2	5.2
Vehicles	11.8	18.5	15.4	10.3	8.8	13.0
Special Conditions[1]	2.3	6.7	2.2	1.8	18.2	6.3
Right of Way	6.0	9.5	14.7	4.0	6.6	8.2
Soft Costs[2]	23.0	21.4	36.1	40.4	25.2	29.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Booz-Allen & Hamilton Inc.; Light Rail Transit Capital Cost Study; prepared for Federal Transit Administration, Office of Technical Assistance and Safety; April 5, 1991.

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[1]Most of the costs in the "Special Conditions" category are for utility relocations. Other costs in this category include demolitions, roadway changes, and environmental treatments.

[2]Soft Costs include feasibility studies, engineering and design studies, project management, project initiation (insurance, mobilization, maintenance of traffic), finance charges, training, and testing.

TABLE 2-15
CAPITAL COST PER ROUTE MILE FOR RECENTLY CONSTRUCTED LIGHT RAIL SYSTEMS
(THOUSANDS OF 1990 NATIONAL DOLLARS[1])

Cost Category	Portland	Sacramento	San Jose	Pittsburgh	Los Angeles	Average
Guideway Elements	$7,013	$2,618	$2,819	$3,016	$5,980	$4,289
Yards and Shops	879	223	948	1,042	1,777	974
Systems	1,567	1,095	1,332	1,608	4,634	2,047
Stations	1,111	576	200	936	2,649	1,094
Vehicles	2,187	1,905	2,600	1,567	3,214	2,295
Special Conditions[2]	427	685	376	276	6,666	1,686
Right of Way	1,118	979	2,480	604	2,417	1,520
Soft Costs[3]	4,283	2,196	6,072	6,136	9,221	5,581
Total	18,585	10,278	16,826	15,185	36,559	19,486

[1]Actual construction costs were converted to 1990 National Dollars using *Means Construction Cost Indices* by city and year. National costs represent the average for 30 major cities.

[2]Most of the costs in the "Special Conditions" category are for utility relocations. Other costs in this category include demolitions, roadway changes, and environmental treatments.

[3]Soft Costs include feasibility studies, engineering and design studies, project management, project initiation (insurance, mobilization, maintenance of traffic), finance charges, training, and testing.

TABLE 2-16
CAPITAL COSTS FOR RECENTLY CONSTRUCTED LIGHT RAIL GUIDEWAYS[1]
(1990 NATIONAL DOLLARS[2] PER LINEAR FOOT)

Type of Construction	Portland	Sacramento	San Jose	Pittsburgh	Los Angeles	Average
At-Grade	$1,205	$413	$609	$460	$636	$665
Elevated Structure	3,041	410		636	2,986	1,768
Elevated Retained Fill		1,077		961	943	999
Elevated Fill				699	616	658
Subway			6,887	7,182	6,935	7,001
Retained Cut		4,973	265	4,904	3,133	3,319

Source: Booz-Allen & Hamilton Inc.; Light Rail Transit Capital Cost Study; prepared for Urban Mass Transportation Administration, Office of Technical Assistance and Safety; April 5, 1991.

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[1]Guideway costs account for 16 to 38 percent of all capital costs for recently constructed light rail systems. Design, engineering, and other "soft" costs are not included in the guideway costs presented in this table. Right-of-way costs are also not included.

[2]Actual construction costs were converted to 1990 National Dollars using *Means Construction Cost Indices* by city and year. National costs represent the average for 30 major cities.

TABLE 2-17
CAPITAL COSTS FOR RECENTLY CONSTRUCTED LIGHT RAIL STATIONS[1]
(1990 NATIONAL DOLLARS[2] IN THOUSANDS)

Type of Construction	Portland	Sacramento	San Jose	Pittsburgh	Los Angeles[3]	Average
At-Grade Center Platform	$492		$156		$981	$543
At-Grade Side Platform	539	$377	185	$1,924	830	771
Elevated					2,661	2,661
Subway				6,806	25,157	15,982

Source: Booz-Allen & Hamilton Inc.; Light Rail Transit Capital Cost Study; prepared for Urban Mass Transportation Administration, Office of Technical Assistance and Safety; April 5, 1991.

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[1]Station costs do not include design, engineering, and other "soft" costs. Right-of-way costs are also not included.

[2]Actual construction costs were converted to 1990 National Dollars using *Means Construction Cost Indices* by city and year. National costs represent the average for 30 major cities.

[3]Costs include provision for connections into other portions of the regional rail network.

TABLE 2-18
CAPITAL COSTS FOR RECENTLY CONSTRUCTED LIGHT RAIL TRANSIT YARDS AND SHOPS[1]
(1990 NATIONAL DOLLARS[2])

Location	Yard and Shop Capital Costs (thousands)	Yard and Shop Capacity (Vehicles)	Cost Per Unit of Capacity (thousands)
Portland	$13,356	100	$133.6
Sacramento	4,087	50	81.7
San Jose	18,863	50	377.3
Pittsburgh	42,838	97	441.6
Los Angeles	40,169	54	743.9
Average			355.6

Source: Booz-Allen & Hamilton Inc.; Light Rail Transit Capital Cost Study; prepared for Urban Mass Transportation Administration, Office of Technical Assistance and Safety; April 5, 1991.

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[1]Design, engineering, and other "soft" costs are not included in the guideway costs presented in this table. Right-of-way costs are also not included.

[2]Actual construction costs were converted to 1990 National Dollars using *Means Construction Cost Indices* by city and year. National costs represent the average for 30 major cities.

TABLE 2-19
COSTS OF RAIL RAPID TRANSIT ROLLING STOCK[1]
(MILLIONS OF DOLLARS)

City	Year	Quantity Ordered	Price for Total Order	Price Per Car
Chicago	1991	256	$207.6	$0.81
Los Angeles	1989	54	63.2	1.17
New York	1990	19	39.3	2.07
San Francisco	1989	150	228.3	1.52
Washington, DC	1989	68	83.3	1.23

SOURCE: Passenger Transport; published by American Public Transit Association, January 2, 1989 to September 30, 1991 issues.

[1]Costs are actual dollars as of order date. Variations in unit costs are due to type of vehicle, size of order, and options.

TABLE 2-20
COSTS OF LIGHT RAIL TRANSIT ROLLING STOCK[1]
(MILLIONS OF DOLLARS)

City	Year	Quantity Ordered	Price for Total Order	Price Per Car
Boston	1991	86	$132.0	$1.53
San Diego	1991	75	122.0	1.63
St. Louis	1990	31	45.4	1.46

SOURCE: Passenger Transport; published by American Public Transit Association, January 15, 1990 to September 30, 1991 issues.

[1]Costs are actual dollars as of order date. Variations in unit costs are due to type of vehicle, size of order, and options.

TABLE 2-21
COSTS OF COMMUTER RAIL ROLLING STOCK[1]
(MILLIONS OF DOLLARS)

Location	Year	Car Type	Quantity Ordered	Price for Total Order	Price Per Car
Florida	1990	Bi-Level	6	$5.9	$0.98
Los Angeles	1990	Bi-Level	40	51.0	1.28
New Jersey	1991		50	45.2	0.90
New York	1990	M-6	39	91.0	2.33
Indiana	1991	7 motorized 10 trailers	17	27.5	1.62

SOURCE: Passenger Transport; published by American Public Transit Association, January 15, 1990 to September 30, 1991 issues.

[1]Costs are actual dollars as of order date. Variations in unit costs are due to type of vehicle, size of order, and options.

TABLE 2-22
COSTS OF VEHICLE REHABILITATION[1]
(MILLIONS OF DOLLARS)

Location	Year	Car Type	Quantity Rehabilitated	Price for Total Order	Price Per Car
RAPID TRANSIT					
New York	1991	R33 Subway	494	$201.0	$0.41
New York	1991	R44 Subway	280	148.4	0.53
New York	1990	R44 Subway	64	36.0	0.56
COMMUTER RAIL					
Maryland	1990		35	7.0	0.20
New Jersey	1991		230	223.1	0.97

SOURCE: Passenger Transport; published by American Public Transit Association, January 15, 1990 to September 30, 1991 issues.

[1]Costs are actual dollars as of order date. Variations in unit costs are due to type of rehabilitation work specified.

TABLE 2-23
LIGHT RAIL VEHICLE CHARACTERISTICS

Vehicle Characteristics	Single Unit		Articulated	
	PCC Car	Canadian Light Rail Vehicle	San Diego, Edmonton, Calgary	San Francisco Boston
Length (m)	14.2	15.4	23.1	21.6
Width (m)	2.5	2.6	2.7	2.7
No. of Doors	2	4 per side	4 per side	3 per side
Size of Doors (m)	1.68	1.52	1.30	1.40
Seated Capacity	46	46	64	52-68
Standing Capacity	56	55	97	167
Acceleration Rate (m/s/s)	1.92	1.47	1.32	1.25
Braking Rate (m/s/s)	1.61	1.56	Not Available	1.57
Jerk Rate (m/s/s/s)	1.34-2.68	1.12-1.78	Not Available	Not Available
Minimum Horizontal Curve Radius (m)	9.8	11.0	35.0	32.0

SOURCE: Canadian Transit Manual, 2nd Edition

TABLE 2-24
TYPICAL SPACE REQUIREMENTS FOR SEATED AND STANDING PASSENGERS

	Square Feet Per Passenger (net)[1]
SEATED PASSENGERS	
Commuter Rail	4 to 6
Urban Rail Transit	3 to 5
STANDING PASSENGERS	
Maximum scheduled load capacity recommended by the 1985 Highway Capacity Manual	2.4 to 2.8
Maximum practical capacity (crush loads)	1.8

SOURCE: 1985 Highway Capacity Manual

[1]Excludes nonusable space. For seated passengers, includes space consumed by seat plus space between seats for legs. For standing passengers, based on clear floor area per standee.

TABLE 2-25
RAIL TRANSIT STATION DWELL TIMES
(SECONDS)

Line	Time of Day	Mean Dwell Time	Standard Deviation
Lexington Ave. Express New York City	PM Peak	53	17
Evanston Express Chicago	PM Peak	42	14
Green Line (LRV) Boston	PM Peak	58	24
Milwaukee Line Chicago	Post PM Peak	19	6

SOURCE: 1985 *Highway Capacity Manual*

CHAPTER 3

BUS TRANSIT

This chapter provides quantitative information on the following characteristics of bus systems:

- Speeds
- Operating costs
- Labor requirements
- Energy consumption
- Capital and rehabilitation costs
- Performance characteristics
- Capacities
- Accident rates

Information on speeds, accident rates, operating costs, labor requirements, and energy consumption in this chapter are summarized (in the form of average, high, and low values) from 1989 UMTA Section 15 reports. Section 15 data on the characteristics of individual bus systems with more than 250 vehicles operated in maximum service are presented in Appendix C. Section 15 data on trolley bus systems are also presented in Appendix C.

TABLE 3-1
TYPICAL PEAK HOUR BUS TRAVEL TIMES BY COMPONENT
(MINUTES PER MILE)

Component	CBD	City	Suburbs
Traffic Delay[1]	3.00	0.90	0.70
Passenger Stops	3.00	1.20	0.50
Moving	5.50	3.90	3.00
Total	11.50	6.00	4.20
Speed in miles per hour	5.2	10.0	14.3

SOURCE: Herbert S. Levinson; "Analyzing Transit Time Performance"; Transportation Research Record 915; 1983.

[1]Traffic delay is the added travel time due to other vehicles and traffic control devices.

TABLE 3-2
EFFECTS OF STOPS AND TRAFFIC DELAY ON BUS SPEEDS
(MILES PER HOUR)

Time Per Stop (seconds)	Stops Per Mile	Speed (mph) by Traffic Delay[1]		
		0.0 min./mile (No Traffic Delay)	0.7 min./mile (Typical Suburban Peak Period)	3.0 min./mile (Typical CBD Peak Period)
10	2	25.0	19.4	11.1
	4	18.3	15.1	9.6
	6	14.0	12.0	8.2
	8	11.3	10.0	7.2
	10	8.6	7.8	6.0
20	2	22.0	17.5	10.5
	4	15.3	13.0	8.8
	6	11.3	10.0	7.2
	8	9.0	8.1	6.0
	10	6.9	6.4	5.1
30	2	19.5	15.9	9.9
	4	13.0	11.3	7.9
	6	9.5	8.6	6.5
	8	7.5	6.9	5.5
	10	5.8	5.4	4.5

SOURCE: Herbert S. Levinson; "Analyzing Transit Time Performance"; Transportation Research Record 915; 1983.

[1]Traffic delay is the added travel time due to other vehicles and traffic control devices. Speeds are calculated assuming a free-flow speed of 35 miles per hour with no stops or traffic delay.

TABLE 3-3

BUS OPERATING COSTS PER UNIT OF SERVICE
BY SYSTEM SIZE AND PEAK TO BASE RATIO

System Size[1] and Peak to Base Ratio[2]	Operating Cost Per Revenue Vehicle Mile	Per Revenue Vehicle Hour	Per Peak Vehicle (thousands)
250 or More Buses			
Ratio ≥ 2.00 (16)[3]	$4.61	$64.24	$148
Ratio < 2.00 (18)	4.82	59.77	184
100-249 Buses			
Ratio ≥ 2.00 (20)	3.80	57.81	120
Ratio < 2.00 (30)	3.75	47.62	138
50-99 Buses			
Ratio ≥ 1.75 (18)	3.79	52.53	103
Ratio < 1.75 (15)	3.54	55.28	136
25-49 Buses			
Ratio ≥ 1.50 (28)	2.85	38.35	96
Ratio < 1.50 (45)	2.88	38.10	116
Fewer Than 25 Buses			
Ratio ≥ 1.50 (30)	2.59	36.00	83
Ratio < 1.50 (56)	2.56	34.94	101
All Motor Buses (363)[4]	$3.09	$42.70	$112
Trolley Buses (5)[5]	$5.77	$60.97	$169

SOURCE: UMTA Section 15 data for 1989

[1]Vehicles operated in maximum service.

[2]Vehicles operated in average PM peak divided by vehicles operated in average base period.

[3]Numbers in parentheses are the number of bus systems for which data are available.

[4]The complete motor bus data base includes several transit systems for which peak to base ratios are not available. Data are missing for some of the above variables for a few transit systems.

[5]Four of the five trolley bus systems are part of systems in the largest size class above. Dayton is in the second size class.

TABLE 3-4
BUS OPERATING COSTS AND EMPLOYEES PER PLACE MILE[1] BY SYSTEM SIZE

Size of System[2]	Operating Cost Per 1,000 Place Miles	Employees Per 1,000 Place Miles
250 or More Buses (34)[3]		
Average	$ 70	1.36
Low	45	0.90
High	137	2.24
100-249 Buses (53)		
Average	58	1.18
Low[4]	26	0.56
High	115	2.30
50-99 Buses (38)		
Average	59	1.25
Low	30	0.64
High	114	2.09
25-49 Buses (82)		
Average	52	1.30
Low[4]	25	0.66
High[4]	95	2.05
Fewer Than 25 Buses (156)		
Average	64	1.91
Low[4]	19	0.63
High[4]	182	4.20
All Motor Buses (363)	$ 60	1.54
Trolley Buses (5)	$ 83	2.28

SOURCE: UMTA Section 15 data for 1989

[1]Place miles (or revenue capacity miles) are calculated as revenue vehicle miles times the average passenger capacity (seated plus standing) of the active vehicles in the fleet.

[2]Vehicles operated in maximum service.

[3]Numbers in parentheses are the number of bus systems for which data are available.

[4]Lows and highs in these size classes exclude a few systems with extreme values.

TABLE 3-5
BUS LABOR INPUTS PER UNIT OF SERVICE BY SYSTEM SIZE

Size of System[1]	Employees (Full Time Equivalents) Per 1,000 Rev. Veh. Miles	Per 1,000 Rev. Veh. Hours	Per 1,000 Passenger Miles	Per Peak Vehicle
250 or More Buses (34)[2]				
Average	0.091	1.19	7.75	3.19
Low	0.058	0.89	3.01	2.29
High	0.157	1.77	13.64	4.78
100-249 Buses (53)				
Average	0.077	1.05	7.72	2.70
Low	0.037	0.62	1.45	0.60
High	0.162	1.48	14.87	7.08
50-99 Buses (38)				
Average	0.075	1.13	9.57	2.39
Low	0.045	0.69	1.76	0.88
High	0.138	2.38	36.54	3.71
25-49 Buses (82)				
Average	0.067	0.90	11.42	2.51
Low	0.047	0.61	3.46	1.54
High	0.099	1.23	22.04	3.73
Fewer Than 25 Buses (156)				
Average	0.070	0.98	24.46	2.57
Low[3]	0.043	0.06	0.89	1.00
High[3]	0.219	1.76	96.45	5.77
All Motor Buses (363)	0.073	1.01	15.82	2.61
Trolley Buses (5)[4]	0.160	1.57	12.55	4.50

SOURCE: UMTA Section 15 data for 1989

[1]Vehicles operated in maximum service.

[2]Numbers in parentheses are the number of bus systems for which data are available.

[3]Lows and highs for the smallest size category exclude a few systems with extreme values.

[4]Four of the five trolley bus systems are part of systems in the largest size class above. Dayton is in the second size class.

TABLE 3-6
BUS LABOR INPUTS PER THOUSAND REVENUE VEHICLE MILES
BY TYPE OF EMPLOYEE AND BY SYSTEM SIZE

Size of System[1]	Vehicle Operators Per 1,000 Rev. Veh. Miles	Vehicle Mechanics[3] Per 1,000 Rev. Veh. Miles	Other Employees Per 1,000 Rev. Veh. Miles	Total Employees Per 1,000 Rev. Veh. Miles
250 or More Buses (34)[2]				
Average	0.051	0.012	0.028	0.091
Low	0.033	0.007	0.015	0.058
High	0.085	0.022	0.050	0.157
100-249 Buses (53)				
Average	0.048	0.009	0.020	0.077
Low[4]	0.020	0.003	0.006	0.037
High[4]	0.082	0.027	0.031	0.126
50-99 Buses (38)				
Average	0.047	0.008	0.020	0.075
Low	0.028	0.002	0.010	0.045
High	0.089	0.019	0.031	0.138
25-49 Buses (82)				
Average	0.044	0.007	0.016	0.068
Low	0.030	0.002	0.008	0.047
High	0.072	0.015	0.034	0.099
Fewer Than 25 Buses (156)				
Average	0.044	0.007	0.019	0.070
Low[4]	0.023	0.000	0.003	0.043
High	0.118	0.029	0.088	0.219
All Motor Buses (363)	0.045	0.008	0.019	0.073
Trolley Buses (5)[5]	0.078	0.021	0.061	0.160

SOURCE: UMTA Section 15 data for 1989

[1]Vehicles operated in maximum service.

[2]Numbers in parentheses are the number of bus systems for which data are available.

[3]"Mechanics" are "revenue vehicle inspection and maintenance" employees.

[4]Lows and highs in these size classes exclude a few systems with extreme values.

[5]Four of the five trolley bus systems are part of systems in the largest size class above. Dayton is in the second size class.

TABLE 3-7
BUS LABOR INPUTS PER THOUSAND REVENUE VEHICLE HOURS
BY TYPE OF EMPLOYEE AND BY SYSTEM SIZE

Size of System[1]	Vehicle Operators Per 1,000 Rev. Veh. Hours	Vehicle Mechanics[3] Per 1,000 Rev. Veh. Hours	Other Employees Per 1,000 Rev. Veh. Hours	Total Employees Per 1,000 Rev. Veh. Hours
250 or More Buses (34)[2]				
Average	0.67	0.15	0.37	1.19
Low	0.54	0.10	0.22	0.89
High	0.98	0.23	0.66	1.77
100-249 Buses (53)				
Average	0.66	0.12	0.27	1.05
Low	0.48	0.05	0.10	0.62
High	0.99	0.29	0.58	1.48
50-99 Buses (38)				
Average	0.72	0.12	0.30	1.13
Low	0.44	0.04	0.13	0.69
High	1.61	0.32	0.73	2.38
25-49 Buses (82)				
Average	0.59	0.10	0.22	0.91
Low[4]	0.43	0.03	0.11	0.61
High	0.88	0.19	0.50	1.23
Fewer Than 25 Buses (156)				
Average	0.61	0.10	0.27	0.98
Low[4]	0.35	0.02	0.04	0.53
High[4]	1.44	0.32	1.06	1.76
All Motor Buses (363)	0.63	0.11	0.27	1.01
Trolley Buses (5)[5]	0.76	0.20	0.61	1.57

SOURCE: UMTA Section 15 data for 1989

[1]Vehicles operated in maximum service.

[2]Numbers in parentheses are the number of bus systems for which data are available.

[3]"Mechanics" are "revenue vehicle inspection and maintenance" employees.

[4]Lows and highs in these size classes exclude a few systems with extreme values.

[5]Four of the five trolley bus systems are part of systems in the largest size class above. Dayton is in the second size class.

TABLE 3-8
BUS FACILITY CONSTRUCTION COSTS
(1990 DOLLARS)

Facility Type	Number of Projects	Cost Per Assigned Vehicle ($)		Cost Per Square Foot ($)	
		Average	Range	Average	Range
With Indoor Vehicle Storage	7	$142,300	$62,700 to 240,000	$89	$71 to 112
Without Indoor Vehicle Storage	7	91,700	44,000 to 140,000	141	70 to 207

SOURCE: Passenger Transport; published by American Public Transit Association; January 2, 1989 to September 30, 1991 issues

TABLE 3-9
REHABILITATION COSTS FOR 35 FOOT BUSES

Location	Year	Quantity Rehabilitated	Price Per Bus
Dubuque	1990	10	$80,000
Monterey	1990	15	140,000[1]
Westchester County	1991	20	50,000

SOURCE: Passenger Transport; published by American Public Transit Association; January 15, 1990 to September 30, 1991 issues

[1]Includes addition of wheelchair lift which added about $20,000 per bus to the rehabilitation cost.

TABLE 3-10
TYPICAL COST AND MILEAGE FOR TRANSIT BUS ENGINE AND TRANSMISSION REBUILDS

	Cost	Mileage
Engine	$4,850	225,000
Transmission	$2,150	120,000

SOURCE: Based on D. W. Carter, R. Drake, and J. Sims; "Vehicle Replacement Strategies: Opportunities for Efficiencies"; Transportation Research Record 1266; 1990.

TABLE 3-11
COSTS OF HEAVY DUTY BUSES
(1990 DOLLARS)

Bus Type	Number of Purchases	Total Number of Buses Purchased	Average Cost Per Bus	Range of Cost Per Bus
60′ Articulated	2	30	$279,900	$193,000-297,000
40′ Suburban	1	162	228,400	
40′ Transit	9	686	178,000	160,000-201,000
35′ Transit	2	45	174,700	172,000-196,000
30′ Transit	2	43	170,900	150,000-174,000

SOURCE: Passenger Transport; published by American Public Transit Association; January 15, 1990 to September 30, 1991 issues.

NOTE: Variations in costs are due to size of order, vehicle configuration, and options.

TABLE 3-12
COST RANGE FOR SMALL BUSES
(1990 DOLLARS)

Type	Gross Vehicle Weight Rating (pounds)	Cost Range
Light Duty (truck-type cab chassis)	9,500-12,500	$30,000-60,000
Light Duty (motorhome-type chassis)	14,500-18,500	45,000-75,000
Medium Duty (rear engine chassis)	16,500-20,500	65,000-110,000
Heavy Duty (integrated body and chassis)	22,500-26,000	125,000-175,000

SOURCE: F. Johnson; "What About Small Buses"; Bus Ride; July 1991

TABLE 3-13
DIMENSIONS OF TYPICAL TRANSIT BUSES

Length	40′ (12.2 m)
Width	8′6" (2.6 m)
Height	10′9" (3.3 m)
Front Overhang	7′4" (2.2 m)
Rear Overhang	9′5" (2.9 m)
Inside Turning Radius	30′ (9.1 m)
Outside Turning Radius	47′ (14.3 m)
Outside Turning Radius with Overhang	51′2" (15.6 m)
Steps from Ground	1′5" (0.43 m)
Front Door Clear Opening	2′6" (0.76 m)
Rear Door Clear Opening	2′2" (0.66 m)
Empty Weight	25,480 pounds (11,558 kg)
Gross Weight	36,640 pounds (16,620 kg)
Wheelbase	23′9" (7.2 m)

SOURCE: Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

TABLE 3-14
DIMENSIONS OF SMALL BUSES

Manufacturer - Model	Gross Weight (pounds)	Length (feet and inches)	Passenger Seats	Wheelbase (inches)	Width (inches)
Amtran - Vanguard	10,000	16' 11"	17	125	96
Bus Industries of America - Orion II	18,000	25'	22	236	96
Champion - Challenger	11,900	24'	24	110	96
Chance - RT52	24,000	25' 11"	23	170	96
Collins - Diplomat	12,200	25'	25	136 to 176	96
Diamond Coach - VIP 2500	11,000	24' 7"	18 to 25	176	96
Eldorado - Aerotech	11,800	24'	25	176	96
Gillig - Spirit	29,500	28'	23 to 29	139	96
Lewis Mfg. - Reddi Bus	9,500	20' 6"	15	138	80
National Coach - Squire	10,300	20' 6"	14 to 23	145	87
New Goshen - GC II	11,500 to 16,000	20' 6" to 31' 5"	17 to 19	158 to 186	96
Stewart & Stevenson - S-25	18,340	25' or 28'	14 to 28	158 to 190	90
Thomas - Citiliner/ Transitliner	28,000	30'	30	181	96
Wayne - Chaperone II	11,500	21' 4"	21	158	96

SOURCE: "Shuttle Buses Come of Age; Modes Uses Grow"; *Metro Magazine*; July/August 1991

TABLE 3-15
TYPICAL TRANSIT BUS PERFORMANCE CHARACTERISTICS

Acceleration (mph/sec)	
0-10 mph	3.33
10-30 mph	2.22
30-50 mph	0.95
Normal Deceleration (mph/sec)	2-3
Top Speed (mph)	65
Metric Units	
Acceleration (km/h/sec)	
0-16 km/h	5.36
16-48 km/h	3.57
48-80 km/h	1.53
Normal Deceleration (km/h/sec)	3.2-4.8
Top Speed (km/h)	105

SOURCE: Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

TABLE 3-16
TYPICAL BUS CAPACITIES

Type of Bus	Length (feet)	Width (feet)	Typical Crush-Load Capacity[1]		
			Seats	Standees	Total
Minibus	18-25	6.5-8.0	15-25	0-15	15-40
Conventional Transit	30	8.0	36	19	55
	35	8.0	45	25	80
	40	8.5	53	32	85
Articulated Transit	55	8.5	66	34	100
	60	8.5	73	37	110

SOURCE: 1985 Highway Capacity Manual

[1]The *Highway Capacity Manual* recommends against using crush load capacities for scheduling. For the 53-seat, 340 square foot bus with a crush load capacity of 85 passengers, the *Highway Capacity Manual* recommends a maximum scheduled load of 80 passengers.

TABLE 3-17
MINIMUM DESIRABLE LENGTHS FOR CURB BUS LOADING ZONES

Type of Stop	Single Bus (L=Bus Length in feet)		Each Additional Bus
	Wheel 6" from curb	Wheel 1′ from curb	
Near side	L + 85	L + 65	L + 5
Far side			
40′+ street width	L + 55	L + 40	L
32-39′ street width	L + 70	L + 55	L
Midblock			
40′+ street width	L + 135	L + 100	L
32-39′ street width	L + 150	L + 115	L

SOURCE: Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

TABLE 3-18
BOARDING AND ALIGHTING TIMES
(SECONDS PER PASSENGER)

ALIGHTING PASSENGERS	
Very little hand baggage and parcels; few transfers	1.5-2.5
Moderate amount of hand baggage or many transfers	2.5-4.0
Considerable baggage from racks (intercity runs)	4.0-6.0
BOARDING PASSENGERS	
No fare payment on boarding	1.5-2.5
Single coin or token with fare box	2.0-3.0
Multiple coin cash fares	3.0-4.0
Zone fares prepaid and registered on bus	4.0-6.0
Multiple zone fares; cash; including registration on bus	6.0-8.0

SOURCE: *1985 Highway Capacity Manual*

TABLE 3-19
BUS ACCIDENT RATES PER REVENUE VEHICLE MILE BY SYSTEM SIZE

Size of System[1]	Accidents Per Million Revenue Vehicle Miles	Fatalities Per Million Revenue Vehicle Miles	Injuries Per Million Revenue Vehicle Miles
250 or More Buses (34)[2]	65	0.09	39
100-249 Buses (53)	59	0.07	25
50-99 Buses (38)	51	1.38	20
25-49 Buses (82)	44	0.11	19
Fewer Than 25 Buses (156)	37	0.08	14
All Motor Buses (363)	46	0.22	20
Trolley Buses (5)[3]	133	0.00	55

SOURCE: UMTA Section 15 data for 1989

[1]Vehicles operated in maximum service.

[2]Numbers in parentheses are the number of bus systems for which data are available.

[3]Four of the five trolley bus systems are part of systems in the largest size class above. Dayton is in the second size class.

TABLE 3-20
BUS ENERGY CONSUMPTION BY SYSTEM SIZE

Size of System[1]	Miles Per Gallon	Gallons Per Hundred Vehicle Miles	Gallons Per Hundred Passenger Miles
1,000 or More Buses (6)[2]	3.2	30.9	2.2
500-999 Buses (12)	3.5	28.4	2.9
250-499 Buses (16)	3.6	27.9	2.7
100-249 Buses (53)	3.7	26.7	2.7
50-99 Buses (38)	4.0	25.1	3.0
25-49 Buses (82)	4.0	25.1	3.9
Fewer Than 25 Buses (156)	4.2	23.6	4.3
All Motor Buses (363)	3.6	28.0	2.7

SOURCE: UMTA Section 15 data for 1989

[1]Vehicles operated in maximum service.

[2]Numbers in parentheses are the number of bus systems for which data are available.

CHAPTER 4

AUTOMOBILES, TRUCKS, AND THE HIGHWAY SYSTEM

This chapter provides quantitative information on characteristics of automobiles, trucks, and the highway system, including the following:

- Freeway capacity and the effects of traffic volumes on speed
- Gasoline prices and fuel economies of highway vehicles
- Automobile ownership and operating costs
- Effects of congestion and pavement condition on vehicle operating costs
- Air pollutant emission rates
- Unit costs for various types of highway improvements
- Construction and operating costs for parking lots and garages
- Value of vehicle travel time
- Accident rates and costs

TABLE 4-1
EFFECT OF LATERAL CLEARANCE AND LANE WIDTHS ON FREEWAY CAPACITIES
(ADJUSTMENT FACTOR[1])

Distance from Obstruction to Travelled Pavement[2]	4-Lane Freeway (2 lanes each direction)			6- or 8-Lane Freeway (3 or 4 lanes each direction)		
	12' Lanes	11' Lanes	10' Lanes	12' Lanes	11' Lanes	10' Lanes
6' or more	1.00	0.97	0.91	1.00	0.96	0.89
4'	0.99	0.96	0.90	0.99	0.95	0.88
2'	0.97	0.94	0.88	0.97	0.93	0.87
0'	0.90	0.87	0.82	0.94	0.91	0.85

Comments

See next page

SOURCE: 1985 *Highway Capacity Manual.*

[1]Ideal capacities are multiplied by the factors in this table to account for the effects of lane widths and lateral clearances.

[2]Obstructions are assumed on one side of the roadway only. The other side of the roadway is assumed to have lateral clearances of 6 or more feet.

TABLE 4-1
EFFECT OF LATERAL CLEARANCE AND LANE WIDTHS ON FREEWAY CAPACITIES
(continued)

Comments

The capacity of a highway segment is the maximum hourly rate at which vehicles can reasonably be expected to pass a given point on the segment during a given time period. The time period used in most capacity analyses is 15 minutes.

The 1985 *Highway Capacity Manual* recommended a value of 2,000 vehicles per lane per hour as the capacity of a freeway under the following ideal conditions:

- Twelve-foot minimum lane widths
- Six-foot minimum lateral clearances to the nearest roadside obstacle
- All passenger cars in the traffic streams[3]
- Driver characteristics typical of weekday commuter traffic

Recommended values for highway capacities will probably be increased in the next edition of the *Highway Capacity Manual*. The Subcommittee on Multilane Highways of the Transportation Research Board's Committee on Highway Capacity and Quality of Service recently approved an increase from 2,000 to 2,200 in the ideal capacity of a multilane highway.

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[3]Passenger car equivalents for trucks, buses, and recreational vehicles are presented in Table 4-3.

TABLE 4-2
EFFECT OF TRAFFIC VOLUME ON FREEWAY SPEEDS

Volume-to-Capacity Ratio	Average Travel Speed (mph)[1]
0.30	60
0.50	58
0.70	55
0.80	52
0.90	48
0.95	44
1.00	30

Comments

Speeds are relatively insensitive to traffic volume at volume-to-capacity ratios below 0.70. However, speeds drop sharply as volume-to-capacity ratios approach 1.00. When the number of vehicles attempting to use a freeway segment exceeds its capacity, traffic flow breaks down, resulting in stop-and-go conditions with average speeds below 30 miles per hour.

SOURCE: 1985 *Highway Capacity Manual*

[1]A design speed of 70 miles per hour is assumed.

TABLE 4-3
PASSENGER CAR EQUIVALENTS FOR FREEWAY CAPACITY

Vehicle Type	Passenger Car Equivalents by Type of Terrain		
	Level	Rolling	Mountainous
Trucks[1]	1.7	4.0	8.0
Buses	1.5	3.0	5.0
Recreational Vehicles	1.6	3.0	4.0

Comments

Passenger car equivalents are used to account for the fact that, on a per vehicle basis, heavy vehicles usually have a greater effect on congestion than lighter vehicles. Primarily because of their acceleration characteristics, the effect of heavy vehicles on congestion is greater on hills.

SOURCE: 1985 *Highway Capacity Manual*

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[1]A weight-to-horsepower ratio of 200 is assumed.

TABLE 4-4
AVERAGE OPERATING COST FOR AN
INTERMEDIATE-SIZED PASSENGER CAR
(Cents Per Mile, Current-Year Dollars)

Year	Variable Cost				Fixed Cost[1]	Total Cost
	Gas & Oil	Maintenance	Tires	Subtotal		
1985	6.2	1.2	0.6	8.0	19.2	27.2
1986	4.5	1.4	0.7	6.6	23.0	29.6
1987	4.8	1.6	0.8	7.2	25.4	32.6
1988	5.2	1.6	0.8	7.6	25.8	33.4
1989	5.2	1.9	0.8	7.9	30.3	38.2
1990	5.4	2.1	0.9	8.4	32.6	41.0

SOURCE: Compiled by the Motor Vehicle Manufacturer's Association from "Your Driving Costs," published by the American Automobile Association. The primary source of this data is Runzheimer and Company.

[1]Fixed cost includes insurance, license and registration, depreciation, and finance charge. A six-year, 60,000 mile retention cycle is assumed in estimating fixed cost.

TABLE 4-5
AVERAGE OPERATING COST FOR AN
INTERMEDIATE-SIZED PASSENGER CAR
(Cents Per Mile, 1990 Dollars)

Year	Variable Cost				Fixed Cost[1]	Total Cost
	Gas & Oil	Maintenance	Tires	Subtotal		
1985	7.5	1.5	0.7	9.7	23.3	33.0
1986	5.4	1.7	0.8	7.9	27.4	35.3
1987	5.5	1.8	0.9	8.3	29.2	37.5
1988	5.7	1.8	0.9	8.4	28.5	36.9
1989	5.5	2.0	0.8	8.3	31.9	40.3
1990	5.4	2.1	0.9	8.4	32.6	41.0

Comments

The variable cost of operating an automobile decreased from 1985 to 1990, due to a decrease in fuel costs. However, the total cost per mile of owning and operating an automobile has been increasing faster than the rate of inflation.

SOURCE: Compiled by the Motor Vehicle Manufacturer's Association from "Your Driving Costs," published by the American Automobile Association. The primary source of this data is Runzheimer and Company. The Consumer Price Index (CPI) was used to convert current-year to constant dollars.

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[1]Fixed cost includes insurance, license and registration, depreciation, and finance charge. A six-year, 60,000 mile retention cycle is assumed in estimating fixed cost.

TABLE 4-6
AVERAGE PRICE OF A NEW CAR, 1970-89

Year	Current Year Dollars	Constant 1989 Dollars
1970	3,542	11,316
1971	3,742	11,462
1972	3,879	11,496
1973	4,052	11,316
1974	4,440	11,169
1975	4,950	11,410
1976	5,418	11,807
1977	5,814	11,899
1978	6,379	12,131
1979	6,847	11,704
1980	7,574	11,403
1981	8,910	12,154
1982	9,890	12,708
1983	10,640	13,247
1984	11,450	13,665
1985	12,022	13,854
1986	12,894	14,588
1987	13,613	14,859
1988	14,485	15,183
1989	15,403	15,403

SOURCE: MVMA Motor Vehicle Facts & Figures '90. Prices were converted to constant dollars using the Consumer Price Index (CPI)

TABLE 4-7
MILES PER GALLON OF HIGHWAY VEHICLES
(1989)

Type of Vehicle	Miles Per Gallon
Passenger Cars	20.54
Motorcycles	50.00
2-Axle 4-Tire Trucks	13.81
Other Single Unit Trucks	7.17
Multiple Unit Trucks	5.34
All Motor Vehicles	15.98

SOURCE: *Highway Statistics 1989*

TABLE 4-8
RETAIL PRICES FOR GASOLINE
(CENTS PER GALLON INCLUDING TAX)

Year	Gasoline Price in Current Dollars	Gasoline Price in Constant 1988 Dollars
1978	65.2¢	118.2¢
1979	88.2	143.8
1980	122.1	175.3
1981	135.3	176.0
1982	128.1	157.1
1983	122.5	145.4
1984	119.8	136.5
1985	119.6	131.6
1986	93.1	100.5
1987	95.7	99.6
1988	96.3	96.3
1989	106.0	101.1
1990	121.7	110.2
1991	119.6	103.9

SOURCE: U.S. Department of Energy, Energy Information Administration.

TABLE 4-9
EFFECT OF PAVEMENT CONDITION ON OPERATING COSTS

A. Operating Cost Factor[1] at a Constant Speed of 35 MPH

Serviceability Index[2]	Automobile	3 Axle Single Unit Truck	5 Axle Combination
4.5	1.000	1.000	1.000
4.0	1.019	1.019	1.022
3.5	1.048	1.046	1.052
3.0	1.096	1.079	1.092
2.5	1.154	1.126	1.148
2.0	1.240	1.183	1.222
1.5	1.317	1.260	1.332
1.0	1.423	1.363	1.502

B. Operating Cost Factor at a Constant Speed of 55 MPH

Serviceability Index	Automobile	3 Axle Single Unit Truck	5 Axle Combination
4.5	1.000	1.000	1.000
4.0	1.020	1.019	1.025
3.5	1.060	1.048	1.062
3.0	1.110	1.083	1.109
2.5	1.190	1.134	1.176
2.0	1.290	1.196	1.266
1.5	1.380	1.282	1.398
1.0	1.500	1.398	1.605

SOURCE: Zaniewski et. al; Vehicle Operating Costs, Fuel Consumption, and Pavement Type and Condition Factors; Report No. FHWA-PL-82-001; prepared for the Federal Highway Administration by Texas Research and Development Foundation; June 1982.

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[1]The operating cost factor has been set to 1.000 for a serviceability index of 4.5. Operating costs include fuel, oil, tires, maintenance, repairs, and use-related depreciation.

[2]Pavement condition is measured in terms of a serviceability index running from 5.0 down to 0.0. The riding qualities of pavements below 3.0 are noticeably inferior to those of new pavements and may be barely tolerable for high speed traffic. Below 2.0, pavements have deteriorated to such an extent that they are in need of resurfacing. Below 1.0, pavements are in extremely deteriorated condition and may even need complete reconstruction.

TABLE 4-10
EFFECT OF SPEED ON AUTOMOBILE OPERATING COSTS[1]
(1990 DOLLARS PER VEHICLE MILE)

	Posted Speed (mph)					
Oper.Speed (mph)	30	35	40	45	50	55
5	$0.193	$0.202	$0.211	$0.219	$0.228	$0.236
10	$0.147	$0.159	$0.172	$0.185	$0.190	$0.195
15	$0.107	$0.120	$0.132	$0.140	$0.150	$0.158
20	$0.087	$0.097	$0.107	$0.117	$0.129	$0.134
25	$0.075	$0.084	$0.092	$0.100	$0.110	$0.117
30	$0.068	$0.075	$0.082	$0.089	$0.097	$0.104
35		$0.069	$0.075	$0.081	$0.088	$0.094
40			$0.073	$0.078	$0.083	$0.089
45				$0.077	$0.081	$0.085
50					$0.079	$0.084
55						$0.082

Comments

As speeds fall below the posted speed limit due to congestion, automobile operating costs increase sharply.

SOURCE: New York State Department of Transportation Highway User Cost Accounting Micro-Computer Package (adjusted to represent 1990 conditions). The model is described in M.S. Pasko and L.H. Adams; "New York State Develops Micro-Computer-Based Programs to Determine the User Benefits of Highway Capacity Improvements"; prepared for TRB Annual Meeting; January 1990.

[1]Vehicle operating costs include gasoline, oil, tires, maintenance, and repair. Depreciation, insurance, and other fixed costs are not included.

TABLE 4-11
VALUE OF VEHICLE TRAVEL TIME BY VEHICLE CLASS
(1990 DOLLARS PER VEHICLE HOUR)

Vehicle Class	Value of Travel Time[1] (Dollars Per Vehicle Hour)
Automobiles	$10.34
4-Tire Trucks	11.74
6-Tire Trucks	22.11
3+ Axle Single Unit Trucks	25.42
4 Axle Combinations	28.16
5 Axle Combinations	28.33
Transit Buses	72.79
All Vehicles -- Urban	10.92
All Vehicles -- Rural	13.45

[1] Costs for on-the-job travel include labor wages and fringes, vehicle costs, and inventory costs. For off-the-job travel, the value of time was assumed to be 60 percent of the wage rate for drivers and 45 percent of the wage rate for passengers.

SOURCE: Highway Economic Requirements System (1991)

TABLE 4-12
PARKING CONSTRUCTION COSTS[1]
(1989 DOLLARS)

Type of Facility	Representative Conditions (1989)		
	Cost Per Square Foot	Square Feet Per Space	Cost Per Space
Surface Lot	$6.00	305	$1,830
2 Level Garage	26.00	315	8,190
3+ Level Garage	32.00	320	10,240
Underground Garage	58.00	320	18,560

SOURCE: Robert A. Weant and Herbert S. Levinson; Parking; Eno Foundation for Transportation; 1990.

[1]Construction costs include 15 percent for engineering, architecture, and contingencies. Land costs are not included.

TABLE 4-13
ILLUSTRATIVE ANNUAL OPERATING COSTS FOR PARKING GARAGES[1]
(1989)

Item	Cost Per Space
Payroll[2]	360
Utilities	60
Maintenance	60
Insurance	30
Supplies	18
Miscellaneous	12
Administrative	30
Total	600

SOURCE: Robert A. Weant and Herbert S. Levinson; Parking; Eno Foundation for Transportation; 1990.

[1]Operating costs assume a 600 space garage, 168-hour per week operation, and cashier collection of parking fees. For garages with more spaces, the operating cost per space would be lower.

[2]Including fringe benefits, security patrols, and training.

TABLE 4-14
PARKING CONTROL SERVICE RATES

Type of Control	Design Service Rates (Vehicles Per Hour) Easy Approach[1]	Difficult Approach[2]
Entrance		
Automatic ticket dispenser	525	300
Push button ticket dispenser	450	250
Machine read ticket dispenser	375	200
Coded-card reader	350	225
Proximity-card reader	500	275
Coin or token operated gate	150	100
Fixed fee to cashier with gate	200	150
Fixed fee to cashier without gate	250	200
No required stop	800	550
Exit		
Coded-card reader	350	225
Proximity-card reader	500	275
Token-operated gate	150	100
Fixed fee to cashier with gate	200	150
Fixed fee to cashier without gate	250	200
Variable fee to cashier	150	100
Validated ticket	300	200
Machine read ticket	375	200
with manual license plate check	100	100
with camera license plate check	75	75
No required stop	375	250

SOURCE: Robert A. Weant and Herbert S. Levinson; Parking; Eno Foundation for Transportation; 1990.

[1]Easy or straight approach to control service position

[2]For example, sharp turn within 100 feet of either side of the control position or patrons generally unfamiliar with the facility.

TABLE 4-15
TAXI COMPANY UNIT COSTS
(1990 DOLLARS)

Cost Per Taxi	$38,780
Cost Per Vehicle Mile	$0.95
Cost Per Vehicle Trip	$6.84
Cost Per Passenger	$4.73

SOURCE: Gorman C. Gilbert, Raymond J. Burby, and Charles E. Feibel; Taxicab Operating Characteristics; Center for Urban and Regional Studies, University of North Carolina at Chapel Hill; September 1982.

TABLE 4-16
HIGHWAY IMPROVEMENT COSTS IN URBAN AREAS
(THOUSANDS OF 1989 DOLLARS PER LANE MILE)[1]

Facility/Improvement Type	Built-Up Areas	Outlying Areas
Freeways and Expressways		
Reconstruction with More Lanes	2,283	1,720
Reconstruction with Wider Lanes	1,676	1,210
Pavement Reconstruction	1,171	1,055
Major Widening	935	750
Minor Widening	676	519
Resurfacing with Shoulder Improv.	319	279
Resurfacing	139	128
Other Divided Highways		
Reconstruction with More Lanes	2,056	1,548
Reconstruction with Wider Lanes	1,510	1,089
Pavement Reconstruction	1,058	950
Major Widening	842	676
Minor Widening	608	466
Resurfacing with Shoulder Improv.	288	252
Resurfacing	126	114
Undivided Highways		
Reconstruction with More Lanes	1,850	1,393
Reconstruction with Wider Lanes	1,359	980
Pavement Reconstruction	954	856
Major Widening	757	608
Minor Widening	547	420
Resurfacing with Shoulder Improv.	260	226
Resurfacing	113	104

SOURCE: Jack Faucett Associates; The Highway Economic Requirements System Technical Report; prepared for Highway Needs and Investment Branch, Office of Policy Development, Federal Highway Administration; July 1991

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[1]The improvement costs in this table include right-of-way. The following unit costs (in thousands of dollars per lane-mile) were assumed for right-of-way:

	Built-Up	Outlying
Freeways and Expressways	$455	$182
Other Divided Roads	410	165
Undivided Roads	370	150

TABLE 4-17
ILLUSTRATIVE EMISSION FACTORS BY SPEED AND CALENDAR YEAR
(GRAMS PER MILE)

A. Calendar Year 1985

	Light Duty Vehicles			Heavy Duty Vehicles		
Speed	NMHC[1]	CO[2]	NOX[3]	NMHC	CO	NOX
10	9.12	96.20	2.36	16.61	132.44	21.38
20	5.64	38.65	2.34	11.04	69.52	17.12
30	4.45	24.93	2.39	8.69	45.25	15.62
40	3.79	17.80	2.45	7.57	36.53	16.06
50	3.60	19.99	2.76	7.02	36.57	18.55
60	4.08	44.22	3.77	6.78	45.46	24.17

B. Calendar Year 1990

	Light Duty Vehicles			Heavy Duty Vehicles		
Speed	NMHC	CO	NOX	NMHC	CO	NOX
10	6.55	69.14	1.63	9.38	79.09	18.73
20	4.05	26.76	1.57	6.20	41.65	14.89
30	3.15	16.44	1.46	4.83	27.12	13.52
40	2.65	11.16	1.44	4.16	21.84	13.88
50	2.46	11.75	1.56	3.83	21.75	16.06
60	2.73	26.01	2.15	3.69	26.83	21.05

C. Calendar Year 1995

	Light Duty Vehicles			Heavy Duty Vehicles		
Speed	NMHC	CO	NOX	NMHC	CO	NOX
10	4.92	48.16	1.18	6.29	49.15	12.42
20	3.11	19.30	1.10	4.20	26.00	9.92
30	2.36	11.06	0.92	3.28	16.94	9.04
40	1.96	6.92	0.84	2.81	13.59	9.29
50	1.75	6.55	0.88	2.57	13.44	10.73
60	1.88	14.49	1.21	2.47	16.41	14.01

(continued)

[1]Non-methane hydrocarbons

[2]Carbon monoxide

[3]Oxides of nitrogen

TABLE 4-17 (continued)

D. Calendar Year 2000

Speed	Light Duty Vehicles NMHC	CO	NOX	Heavy Duty Vehicles NMHC	CO	NOX
10	4.23	30.95	0.98	4.93	34.32	9.79
20	2.73	15.86	0.90	3.30	18.25	7.84
30	2.04	8.82	0.70	2.56	11.90	7.15
40	1.66	5.28	0.61	2.18	9.51	7.35
50	1.46	4.69	0.61	1.98	9.32	8.49
60	1.51	10.36	0.83	1.90	11.23	11.06

WARNING: MOBILE 4.1 does not model most 1993 or later Clean Air Act Requirements. Emission factors for calendar years 1993 and later are affected.

Assumed Conditions for Emission Factor Calculations

- Maximum Temperature -- 84 (F)
- Minimum Temperature -- 60 (F)
- Ambient Temperature -- 78.1 (F)
- Altitude -- 500 feet
- No Inspection/Maintenance (I/M) Program
- No Anti-Tampering Program
- Non-Methane Hydrocarbons (NMHC) include exhaust, evaporative, running loss, and resting loss. Refueling NMHC are not included.
- Percent of vehicles in cold start mode -- 20.6
- Percent of vehicles in hot start mode -- 27.3
- Light Duty (0-8,500 Pounds) Vehicle Mix

	1985	1990	1995	2000
Motorcycles	1.1	0.9	0.8	0.8
Automobiles				
Gasoline	72.4	70.2	68.3	66.9
Diesel	2.1	1.0	0.5	0.2
Light Trucks				
Gasoline	23.7	27.7	30.3	32.0
Diesel	0.7	0.2	0.1	0.1

- Heavy Duty (Over 8,500 Pounds) Vehicle Mix

	1985	1990	1995	2000
Gasoline	38.3	32.4	29.4	27.3
Diesel	61.7	67.6	70.6	72.7

SOURCE: MOBILE 4.1 (US EPA Mobile Source Emission Factor Model)

TABLE 4-18
INCIDENTS PER MILLION VEHICLE MILES BY HIGHWAY FUNCTIONAL CLASS

	Police-Reported Crashes	Deaths	Nonfatal Injuries	Crash-Involved Vehicles
Urban				
Interstate	1.06	0.009	0.73	1.88
Other Freeway	1.13	0.015	0.66	2.08
Other Prin. Art.	5.83	0.019	3.85	11.20
Minor Arterial	5.74	0.019	3.52	10.52
Collector	5.29	0.017	3.12	8.91
Local	8.63	0.018	3.49	13.08
Rural				
Interstate	0.69	0.015	0.52	0.90
Other Prin. Art.	1.48	0.031	0.96	2.45
Minor Arterial	1.75	0.033	1.34	2.69
Major Collector	2.06	0.032	1.43	3.09
Minor Collector	3.57	0.064	2.70	4.72
Local	3.52	0.042	1.92	4.96

SOURCES: Fatalities: *Fatal Accident Reporting System (FARS), 1988-1989.*
Crashes, Injuries, and Vehicles: *National Accident Sampling System (NASS), 1982-1984.*
Vehicle Miles: *Highway Statistics.*

TABLE 4-19
COSTS OF POLICE-REPORTED CRASHES BY HIGHWAY FUNCTIONAL CLASS
(1990 DOLLARS)

Highway Functional Class	Cost Per Crash	Cost Per 1,000 Vehicle Miles
Urban		
Interstate	$58,937	$62
Other Freeway	62,971	71
Other Principal Arterial	37,829	221
Minor Arterial	37,662	216
Collector	36,554	193
Local	25,472	220
Rural		
Interstate	101,679	70
Other Principal Arterial	108,800	161
Minor Arterial	94,866	166
Major Collector	91,470	188
Minor Collector	94,068	336
Local	76,224	269

(continued)

TABLE 4-19
COSTS OF POLICE-REPORTED CRASHES BY HIGHWAY FUNCTIONAL CLASS
(continued)

Notes

Costs cover medical services, ancillary services, emergency services, lost wages, lost household production, lost quality of life, workplace disruption, insurance administration, legal and court, travel delay for uninvolved motorists, and property damage. Costs were computed using the willingness to pay methodology prescribed for valuing life-saving benefits by the U.S. Office of Management and Budget in Regulatory Program of the United States and by FHWA Technical Advisory T-7570.1.

Per fatality and per injury costs were as follows:

Cost/fatality = $2,632,016
Cost/Incapacitating Injury (Severity Class A) = $186,457
Cost/Evident Injury (Severity Class B) = $36,550
Cost/Possible Injury (Severity Class C) = $18,732

Costs were computed using injury distributions from 1982-1984 NASS data.

Source: Miller, Ted, John Viner, Nancy Pindus, et al., The Costs of Highway Crashes, Federal Highway Administration, 1991.

CHAPTER 5

AUTOMATED GUIDEWAY TRANSIT

This chapter presents quantitative information on the following characteristics of 23 automated guideway transit systems:

- Vehicle capacities
- Maximum and average speeds
- Operating and maintenance costs
- Vehicle costs
- Capital costs
- Labor requirements

Appendix D provides more detailed information on the characteristics of each of the 23 AGT systems, including the following:

- System configuration
- Guideway elevation and length
- Number of stations
- Daily operating hours
- Annual system vehicle miles and vehicle hours

TABLE 5-1
AUTOMATED GUIDEWAY TRANSIT FLEET SIZES,
CAPACITIES AND SPEEDS

System	Fleet Size	Vehicle Capacity		Vehicle Speed (mph)	
		Seated	Standing[1]	Max.	Avg.
Atlanta Airport	17	16	34	27	10
Busch Gardens	2	16	69	30	18
Chicago O'Hare Airport	13	8	49	50	23
Dallas/Fort Worth Airport AIRTRANS	51	16	12	17	10
Denver Airport	16	14	42	32	11
Detroit DPM	12	34	66	30	12
Disney World	72	20	0	45	18
Duke	4	4	14	28	14
Fairlane	2	10	14	30	19
Houston WEDway	18	6	6	15	6
Jacksonville DPM	2	12	80	41	16
Las Vegas McCarran Airport	4	4	48	25	17
Las Colinas APT	4	12	33	30	18
Miami Airport	6	2	50	30	10
Miami Metromover	12	16	69	27	8
Morgantown	73	8	13	30	15
Newark Airport	72	12[2]	54[2]	28	14
Orlando Airport	18	0	51	30	9
Pearlridge	4	32[3]	39[3]	8	4
Seattle-Tacoma Airport	24	12	45	26	9
Tampa Airport	10	0	50	30	9
Tampa Airport - Parking Garage	6	8	9	12	4
U.S. Senate Subway	12	9	3	14	N/A

[1] It is measured at 2.5 sq. feet per standee for urban system and 5.0 sq. feet per standee for airport system.

[2] These values are for 6-car train.

[3] These values are for 4-car train.

N/A Not Available

TABLE 5-2
OPERATING AND MAINTENANCE COSTS FOR
AUTOMATED GUIDEWAY TRANSIT SYSTEMS
(1990 Dollars)

System	Cost Per Vehicle-Mile Traveled	Cost Per Equivalent Place Mile[1]	Cost Per Vehicle-Hour
Atlanta Airport	$5.11	$0.10	$51.14
Busch Gardens	9.90	0.12	178.24
Chicago O'Hare Airport	30.61	0.54	704.10
Dallas/Fort Worth Airport AIRTRANS	2.42	0.09	24.23
Denver Airport	5.61	0.10	61.71
Detroit DPM	21.29	0.21	255.53
Duke	6.97	0.39	97.63
Houston WEDway	5.21	0.43	31.29
Jacksonville DPM	6.64	0.07	106.18
Las Vegas McCarran Airport	4.34	0.08	73.74
Las Colinas APT	16.23	0.36	292.17
Miami Airport	2.85	0.05	28.52
Morgantown	3.21	0.15	48.12
Newark Airport	1.35	0.12	18.24
Orlando Airport	4.00	0.08	35.99
Pearlridge	38.82	2.19	155.27
Seattle-Tacoma Airport	1.86	0.03	16.73
Tampa Airport	3.25	0.06	29.22
Tampa Airport - Parking Garage	3.08	0.18	12.30

[1] Equivalent place miles are computed by multiplying the vehicle capacities (seated plus standing) shown in Table 5-1 by vehicle-miles travelled for each system.

TABLE 5-3
AUTOMATED GUIDEWAY TRANSIT VEHICLE COSTS
(1990 Dollars)

System	Cost Per Vehicle ($1,000)	Cost Per Equivalent Passenger Place[1] ($1,000)	Cost Per Pound (Dollars)
Atlanta Airport	$1,087	$22	$0.67
Busch Gardens	850	10	0.06
Dallas/Fort Worth Airport AIRTRANS	484	17	1.80
Denver Airport	1,619	29	0.79
Detroit DPM	2,322	23	0.88
Duke	443	22	0.17
Fairlane	755	31	0.12
Houston WEDway	93	8	0.70
Las Colinas APT	1,300	29	0.27
Miami Airport	751	14	0.17
Morgantown	380	18	3.22
Orlando Airport	937	18	0.29
Seattle-Tacoma Airport	1,012	18	0.95
Tampa Airport	697	14	0.26
Tampa Airport - Parking Garage	421	25	0.27
U.S. Senate Subway	136	11	0.55

[1] Equivalent passenger places per vehicle are determined by the vehicle capacities (seated plus standing) presented in Table 5-1.

TABLE 5-4
AUTOMATED GUIDEWAY SYSTEM CAPITAL COST SUMMARY
(THOUSANDS OF 1990 DOLLARS)

	Atlanta Airport	Busch Gardens	Chicago O'Hare Airport	Dallas/Fort Worth Airtrans	Denver Airport	Detroit DPM
Guideway						
Total Cost	$27,898	3,424	N/A	25,691	12,480	96,477
Percent of Total System Cost	30%	36		21	16	42
Cost Per Lane Mile	$12,183	2,574		2,007	6,746	32,815
Stations						
Total Cost	$14,664	259	N/A	13,861	2,494	Included
Percent of Total System Cost	16%	3		11	3	in
Cost Per Station	$1,466	130		990	624	Guideway
Maint. & Support Capabilities						
Total Cost	$5,372	454	N/A	7,599	3,052[1]	64,016
Percent of Total System Cost	6%	5		6	4	28
Cost Per Lane Mile	$2,346	341		594	1,650	21,774
Power and Utility						
Total Cost	$5,227	785	N/A	10,289	4,751	Included
Percent of Total System Cost	6%	8		8	6	Elsewhere
Cost Per Lane Mile	$2,283	590		804	2,568	
Vehicles						
Total Cost	$18,474	1,699	N/A	25,172	25,896	27,861
Percent of Total System Cost	20%	18		20	32	12
Cost Per Vehicle	$1,087	850		484	1,619	2,322
Command, Control & Communication						
Total Cost	$6,806	1,046	N/A	13,329	9,716	21,853
Percent of Total System Cost	7%	11		11	12	9
Cost Per Lane Mile	$2,972	786		1,041	5,252	7,433
Engineering & Project Management						
Total Cost	$14,017	1,874	N/A	29,547	21,856	21,164
Percent of Total System Cost	15%	20		24	27	9
Cost Per Lane Mile	$6,121	1,409		2,308	11,814	7,199
Total System Cost:	$92,458	9,541	108,899	125,488	80,245	231,371

TABLE 5-4 (continued)

	Disney World	Duke	Fairlane	Houston	Jacksonville	McCarran Airp.
Guideway						
Total Cost	N/A	3,295	4,143	11,610	9,230[2]	N/A
Percent of Total System Cost		22	33	36	29	
Cost Per Lane Mile		5,884	8,455	8,474	6,593	
Stations						
Total Cost	N/A	337	831	7,021	3,610	N/A
Percent of Total System Cost		2	7	22	12	
Cost Per Station		337	416	780	1,203	
Maint. & Support Capabilities						
Total Cost	N/A	Included	235	506	1,950	N/A
Percent of Total System Cost		Elsewhere	2	2	6	
Cost Per Lane Mile			480	369	1,393	
Power and Utility						
Total Cost	N/A	Included	1,939	821	1,340	N/A
Percent of Total System Cost		Elsewhere	15	3	4	
Cost Per Lane Mile			3,957	599	957	
Vehicles						
Total Cost	N/A	1,773	1,510	1,679	6,040[3]	N/A
Percent of Total System Cost		12	12	5	19	
Cost Per Vehicle		443	755	93	3,020	
Command, Control & Communication						
Total Cost	N/A	5,340	1,511	3,534	4,650	N/A
Percent of Total System Cost		36	12	11	15	
Cost Per Lane Mile		9,536	3,084	2,580	3,321	
Engineering & Project Management						
Total Cost	N/A	4,099	2,421	7,079	4,550	N/A
Percent of Total System Cost		28	19	22	15	
Cost Per Lane Mile		7,320	4,941	5,167	3,250	
Total System Cost:	N/A	14,844	12,590	32,251	31,370	9,074

TABLE 5-4 (continued)

	Las Colinas	Miami Airport	Miami DPM	Morgantown	Newark Airport	Orlando Airport
Guideway						
Total Cost	5,477	4,896	N/A	53,741	N/A	7,671
Percent of Total System Cost	22	22		25		20
Cost Per Lane Mile	7,401	9,600		6,249		5,218
Stations						
Total Cost	1,836	5,380	N/A	9,807	N/A	6,134
Percent of Total System Cost	8	24		5		16
Cost Per Station	459	2,690		1,961		1,534
Maint. & Support Capabilities						
Total Cost	1,193	1,475	N/A	8,364	N/A	3,163
Percent of Total System Cost	5	7		4		8
Cost Per Lane Mile	1,612	2,892		973		2,152
Power and Utility						
Total Cost	1,197	830	N/A	13,447	N/A	1,415
Percent of Total System Cost	5	4		6		4
Cost Per Lane Mile	1,617	1,627		1,564		963
Vehicles						
Total Cost	5,200	4,506	N/A	27,731	N/A	7,496
Percent of Total System Cost	21	20		13		20
Cost Per Vehicle	1,300	751		380		937
Command, Control & Communication						
Total Cost	3,538	1,633	N/A	40,285	N/A	8,347
Percent of Total System Cost	14	7		19		22
Cost Per Lane Mile	4,781	3,202		4,684		5,678
Engineering & Project Management						
Total Cost	5,992	3,541	N/A	59,613	N/A	3,994
Percent of Total System Cost	25	16		28		10
Cost Per Lane Mile	8,097	6,943		6,932		2,717
Total System Cost:	24,432	22,261	133,056	212,990	140,400	38,221

TABLE 5-4 (continued)

	Pearl-Ridge	Sea-Tac	Tampa Airport	Tampa Parking Garage	U. S. Senate Subway
Guideway					
Total Cost	N/A	24,696	6,871	2,819	8,208[4]
Percent of Total System Cost		29	24	26	51
Cost Per Lane Mile		14,527	5,090	5,527	12,436
Stations					
Total Cost	N/A	11,033	4,481	583	696
Percent of Total System Cost		13	15	5	4
Cost Per Station		1,839	560	83	232
Maint. & Support Capabilities					
Total Cost	N/A	5,687	1,807	443	455
Percent of Total System Cost		7	6	4	3
Cost Per Lane Mile		3,345	1,339	869	689
Power and Utility					
Total Cost	N/A	3,357	4,412	1,318	829
Percent of Total System Cost		4	15	12	5
Cost Per Lane Mile		1,975	3,268	2,584	1,256
Vehicles					
Total Cost	N/A	24,286	5,572	2,527	1,637
Percent of Total System Cost		29	19	23	10
Cost Per Vehicle		1,012	697	421	136
Command, Control & Communication					
Total Cost	N/A	4,194	2,847	1,307	2,678
Percent of Total System Cost		5	10	12	17
Cost Per Lane Mile		2,467	2,109	2,563	4,058
Engineering & Project Management					
Total Cost	N/A	11,506	3,267	1,804	1,745
Percent of Total System Cost		14	11	17	11
Cost Per Lane Mile		6,768	2,420	3,537	2,644
Total System Cost:	N/A	84,759	29,256	10,801	16,248

[1]Cost includes maintenance facility finish-out.
[2]Cost includes right-of-way construction.
[3]It includes other subsystems costs.
[4]It includes costs associated with current system providing full service while new system is being installed

TABLE 5-5
LABOR INPUTS FOR AGT SYSTEMS SYSTEM

	Personnel per 1000 Vehicle-Hours	Personnel per 10,000 Vehicle-Miles	Personnel per 100,000 Equivalent Place Miles[1]
Atlanta Airport	0.75	0.75	0.15
Busch Gardens	16.36	9.09	1.07
Chicago O'Hare Airport	2.82	1.22	0.21
Dallas/Fort Worth Airport AIRTRANS	0.52	0.52	0.19
Detroit DPM	3.46	2.88	0.29
Disney World	0.20	0.11	0.06
Duke	2.22	1.58	0.88
Houston WEDway	0.36	0.60	0.50
Jacksonville DPM	1.75	1.09	0.12
Las Vegas McCarran Airport	0.82	0.48	0.09
Las Colinas APT	1.50	0.83	0.19
Miami Airport	0.66	0.66	0.13
Morgantown	0.91	0.61	0.07
Orlando Airport	0.47	0.52	0.10
Pearlridge	4.59	11.47	6.46
Seattle-Tacoma Airport	0.20	0.22	0.04
Tampa Airport	0.22	0.25	0.05

[1] Equivalent place miles are computed by multiplying the vehicle capacities (seated plus standing) shown in Table 5-1 by vehicle-miles travelled for each system.

CHAPTER 6

HIGH-OCCUPANCY VEHICLE FACILITIES

This chapter provides quantitative information on the following characteristics of high-occupancy vehicle (HOV) facilities:

- Capital costs
- Operation and maintenance costs
- Enforcement-related information (personnel, costs, fine amounts, violation rates)
- HOV and adjacent facility speeds
- HOV and adjacent facility speeds
- Design guidelines for widths, clearances, design speeds, and grades

TABLE 6-1
CAPITAL COSTS FOR SELECTED HOV PROJECTS[1]

HOV Facility	Capital Costs (millions $)	Route Mileage	Base Year for Cost Estimate	Cost Per Mile (millions $)
SEPARATE R.O.W.				
South Busway (Pittsburgh)	$27.0	4	1977	$6.75
East Busway (Pittsburgh)	93.0 (inc. design)	6.8	1983	13.68
BARRIER-SEPARATED FREEWAY R.O.W.				
I-45N (Houston)	29.0	9.1	1988	3.19
I-45S (Houston)	27.3	6.5	1988	4.20
I-10 (Houston)	32.0	11.5	1989	2.78
US 290 (Houston)	44.0	9.5	1988	4.63
I-10 (Los Angeles)	56.0	11	1973	5.09
San Bernadino (LA)	35.0	0.7	1989	50.00
I-15 (San Diego)	31.4	8	1988	3.93

(continued)

[1]Design costs are not included unless noted.

TABLE 6-1 (continued)

HOV Facility	Capital Costs (millions $)	Route Mileage	Base Year for Cost Estimate	Cost Per Mile (millions $)
BUFFER-SEPARATED RIGHT-OF-WAY				
Route 91 (Los Angeles)	0.3 (inc. design)	8	1984	0.04
Route 55 (Orange Co.)	0.4	11	1984	0.04
Route 405 (Orange Co.)	54	14	1988	3.86
I-4 (Orlando)	14	30	1980	0.47
Montague (Santa Clara)	1.5	5	1985	0.30
San Tomas (Santa Clara)	3.5	11	1985	0.32
I-5 (Seattle)	7.6	6	1985	1.27
SR 520 (Seattle)	0.1	2.8	1973	0.04
I-405 (Seattle)	10.2	6	1986	1.70
CONTRAFLOW FREEWAY RIGHT-OF-WAY				
Lincoln Tunnel (NJ)	0.5 (inc. design)	2.5	1970	0.20
Long Island Xway (NYC)	0.4	2.2	1971	0.18
Gowanus Xway (NYC)	0.4	0.9	1980	0.44
I-45N (Houston)	1.8	9.6	1979	0.19

SOURCE: Compiled from various sources by Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

TABLE 6-2
OPERATION AND MAINTENANCE COST FOR CONTRAFLOW HOV FACILITIES

HOV Facility	Daily Deployment (persons)	Annual Operation and Maintenance Cost
Route 495 --Lincoln Tunnel (New Jersey)	6	$265,000
Long Island Expressway (New York)	5-6	250,000
Gowanus Expressway (New York)	2-3	84,000
US 101 (Marin County, CA)[1]	5-6	300,000
I-45N (Houston)[2]	10-12	600,000

SOURCE: Compiled from various sources by Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

[1]Facility was terminated in 1985.

[2]Facility was terminated in 1984.

TABLE 6-3
OPERATION AND MAINTENANCE COST FOR BARRIER AND BUFFER SEPARATED HOV FACILITIES

HOV Facility	Daily Deployment (persons)	Annual Operation and Maintenance Cost
South Busway, East Busway (Pittsburgh)	0	$65,000
I-10, I-45, US 290 (Houston)	5[3]	450,000
I-395 (Virginia)	2-5[4]	500,000
I-4 (Orlando)	0	205,000
I-5 (Seattle)	0	18,000
SR 520 (Seattle)	0	7,500
I-405 (Seattle)	0	18,000

SOURCE: Compiled from various sources by Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

[3]Manual gates, signs, and lane controls

[4]Remote control gates and signs.

TABLE 6-4
ENFORCEMENT-RELATED INFORMATION FOR SELECTED HOV PROJECTS

HOV Facility	Method of Enforcement	Annual Cost	Peak Hour Violation Rate (percent)	Peak Period Violation Rate (percent)	Fine Amount	No of Persons Assigned to Enforcement
FACILITY IN SEPARATE ROW						
Ottawa, Canada	Charged with trespassing	$200,000	1	1	$53.75	3
Pittsburgh	Citation	$100,000	1	1	$300 + court	4
REVERSIBLE-FLOW						
I-45, I-10, US 290 (Houston)	Special citation areas, vehicles diverted	$60,000	1	14 am, 1 pm	$75	2
I-395 (Virginia)	Citations by mail	$35,000/officer	5	15	$50	2-5
I-15 (San Diego)	Vehicles stopped	NA	3	5	$246 + court	2
2-WAY BARRIER SEPARATED						
I-10 (Los Angeles)	Citation on shoulder	$20,000	11	11	$246 + court	2
2-WAY BUFFER SEPARATED						
Route 55 and I-405 (Orange County)	Special citation areas	$30,000	6	7	$246 + court	6
Route 91 (Los Angeles)	Special citation area	$30,000	7	7	$246 + court	6
I-95 (Fort Lee, NJ)	Vehicles stopped	NA	30	30	$50	1
Moanalua (Honolulu)	Vehicles diverted	$35,000	20	20	$40	3
I-4 (Orlando)	Not enforced	0	75	75	$43.50	0
US 101, Route 237 (San Francisco)	Vehicles diverted	$215,000	5	10	$50-500	1-7
I-5, I-405 (Seattle)	License plates identified and HERO program	NA	11	11	$47	NA
SR 520 (Seattle)	License plates identified and HERO program	NA	8	8	$47	NA

SOURCE: Compiled from various sources by Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

TABLE 6-5
COMPARISON OF HOV AND ADJACENT FACILITY ACCIDENT RATES

	Number of Accidents Per Million Vehicle Miles	
	HOV Lanes	Adjacent Mixed Flow Lanes
BARRIER-SEPARATED FACILITIES		
I-10 (Houston)	1.0	2.4
I-45 (Houston)	2.0	2.4
I-10 (Los Angeles)	0.4	1.1
I-395 (Virginia)	2.3	NA
BUFFER-SEPARATED AND NON-SEPARATED FACILITIES		
I-5 median lanes (Seattle)	3.2	2.1
I-405 outside lanes (Seattle)	3.6	1.3
I-10 (Los Angeles)	3.6	1.4
US 101 (Marin Co.)	2.4	2.0
I-95 (Miami)	1.9	3.6

SOURCE: Compiled from various sources by Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

TABLE 6-6
HOV DESIGN GUIDELINES

	Lane Width (ft)	Lateral Clearance (ft)			Total Pavement Width (ft)			Design Speed (mph)	Vertical Clear. (ft)	Vertical Grades (%)
		Left	Right	Outside	1-Lane	2-Lane Rev.	2-Way			
AASHTO	12.0	4	10-12	NS	26	40	NS	60+	16.5	NS
Caltrans I-5 Busway Standards	12.0	2	8	2	26	36	46	70	18.0	5
Houston METRO Transit Auth.	12.0	4	4	NS	20	40	52	60	16.5	3-6
Orange Co. Transit District Geometric Report, 1985	12.0	2	8	2	22	NS	46	60	17.5	3
Orange Co. CA Transitway Concept Design, 1987	12.0	2-6	8-10	2-10	22-26	NS	46-56	60	15.0	3-6
Ottawa Transit Agency	11.5	NS	10	NS	NS	NS	NS	50	NS	NS
Texas Transitway Design Manual	12.0	5	5	5	22	38	44	60	16.5	6
NCHRP 155 Class A Busway	12.0	4	8-10	NS	NS	36	44	70	18.0	5
Washington State DOT	12.0	4-10	10	NS	26	40	44	50-80	16.5	3-6

SOURCE: Compiled from various sources by Charles A. Fuhs; High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual; Parsons, Brinckerhoff, Quade, & Douglas; 1990.

TABLE 6-7
PEAK HOUR HOV LANE OPERATING CHARACTERISTICS

HOV Project and Location	Average Peak-Hour Volumes						Average Speed (mph)	
	Bus		Van and Carpool		Freeway			
	Vehicle	Person	Vehicle	Person	Vehicle	Person	HOV Lane	Freeway
EXCLUSIVE FACILITIES								
I-10 3+ HOVs (Houston)	35	1,200	90	510	4,660	5,420	53	29
I-10 2+ HOVs (Houston)	35	1,190	1,330	2,715	4,650	4,930	47	35
I-45 (Houston)	70	2,555	180	1450	4,375	5,050	58	24
I-10 (Los Angeles)	75	3,320	835	2735	8,210	10,355	55	24
I-395 (Virginia)	155	5,425	1,575	7500	6,625	8,525	57	26
CONCURRENT FLOW								
Route 91 (Los Angeles)	20	500	1,370	3050	8,000	8,960	53	27
I-95 (Miami)	10	350	1,335	2400	5,850	7,240	50	39
Route 55 (Orange County)	5	80	1,250	2730	6,100	6,710	60	31
Bay Bridge (San Francisco)	195	6,505	1,945	7940	6,655	7,900	22	5
US 101 (San Francisco)	80	2,785	305	940	5,875	8,990	56	37
I-5 (Seattle)	45	1,820	395	1190	7,500	9,000	34	26
SR 520 (Seattle)	55	2,300	255	1060	3,485	3,905	16	7
CONTRAFLOW								
NJ Route 495 (New York City)	725	34,685	NA	NA	4,475	7,380	21	4
US 101 (San Francisco)	150	6,000	NA	NA	7,000	9,450	50	50

SOURCE: Timothy J. Lomax; "Estimating Transportation Corridor Mobility"; Transportation Research Record 1280; 1990.

TABLE 6-8
PEAK HOUR FREEWAY AND HOV LANE VOLUME COMPARISONS

HOV Project and Location	Number of Lanes		Average Peak-Hour Person Volume		Person Volume Per Lane		Person Volume Ratio (HOV/ Freeway)
	HOV	Freeway	HOV	Freeway	HOV	Freeway	
EXCLUSIVE FACILITIES							
I-10 3+ HOVs (Houston)	1	3	1710	5420	1710	1805	0.95
I-10 2+ HOVs (Houston)	1	3	3900	4930	3900	1645	2.37
I-45 (Houston)	1	3	4005	5050	4005	1685	2.38
I-10 (Los Angeles)	1	4	6055	10335	6055	2585	2.34
I-395 (Virginia)	2	4	12925	8525	6465	2130	3.03
CONCURRENT FLOW							
Route 91 (Los Angeles)	1	4	3550	8960	3550	2240	1.58
I-95 (Miami)	1	3	2750	7240	2750	2415	1.14
Route 55 (Orange County)	1	3	2810	6710	2810	2235	1.26
Bay Bridge (San Francisco)	3	16	14445	7900	4815	495	9.75
US 101 (San Francisco)	1	3	3725	8990	3725	2995	1.24
I-5 (Seattle)	1	4	3010	9000	3010	2250	1.34
SR 520 (Seattle)	1	2	3360	3905	3360	1955	1.72
CONTRAFLOW							
NJ Route 495 (NYC)	1	3	34685	7380	34685	2460	14.10
US 101 (San Francisco)	1	4	6000	9450	6000	2365	2.54

SOURCE: Timothy J. Lomax; "Estimating Transportation Corridor Mobility"; Transportation Research Record 1280; 1990.
1.Design costs are not included unless noted.

APPENDIX A

CONSUMER PRICE AND COST INDICES

TABLE A-1
CONSUMER PRICES INDICES -- ALL URBAN CONSUMERS[1]

Year	All Items	Transportation		
		Total[2]	New Cars	Motor Fuel
1982	96.5	97.0	97.4	102.8
1983	99.6	99.3	99.9	99.4
1984	103.9	103.7	102.8	97.9
1985	107.6	106.4	106.1	98.7
1986	109.6	102.3	110.6	77.1
1987	113.6	105.4	114.6	80.2
1988	118.3	108.7	116.9	80.9
1989	124.0	114.1	119.2	88.5
1990	130.7	120.5	121.0	101.2
1991	136.2	123.8	125.3	99.4

SOURCE: *Economic Indicators*; February 1992.

[1]1982-1984 = 100

[2]Includes items not shown separately.

TABLE A-2
HIGHWAY CONSTRUCTION PRICE TRENDS

Year	Common Excavation ($/cu. yd.)	Portland Cement Concrete[1] ($/sq. yd)	Bituminous Concrete ($/ton)	Reinforcing Steel ($/lb.)	Structural Steel ($/cu. yd.)	Structural Concrete ($/cu. yd.)	Composite Index
1981	1.76	14.17	25.63	.438	.790	231.64	94.2
1982	1.59	13.03	24.33	.407	.762	219.63	88.5
1983	1.74	12.69	24.27	.398	.708	213.85	87.6
1984	1.90	13.64	26.52	.409	.709	218.02	92.6
1985	2.24	14.31	28.52	.444	.796	243.60	102.0
1986	2.28	15.63	26.48	.442	.850	236.37	101.1
1987	2.42	14.80	24.65	.441	.885	240.81	100.0
1988	2.72	14.33	24.91	.494	.924	274.12	106.6
1989	2.40	15.17	24.08	.556	1.018	283.40	107.7
1990	2.38	15.91	24.52	.529	1.010	286.18	108.5

SOURCE: Federal Highway Administration; *Price Trends for Federal-Aid Highway Construction*; Third Quarter 1991

[1]Prices for portland cement concrete surfacing assume 9" standard thickness.

TABLE A-3
COST TRENDS FOR HIGHWAY MAINTENANCE AND OPERATIONS[1]

Year	Labor	Material	Equipment	Overhead	Total
1981	136.96	159.31	167.84	130.36	146.29
1982	150.79	171.58	182.78	141.44	160.04
1983	157.58	170.04	188.08	159.40	166.28
1984	165.93	181.77	188.64	177.57	173.93
1985	176.05	194.68	197.13	195.86	184.37
1986	183.80	192.79	218.14	204.73	193.71
1987	192.30	185.27	232.36	220.05	202.53
1988	204.19	182.37	235.79	234.50	210.77
1989	209.63	177.59	254.43	256.10	219.09
1990	217.53	181.71	168.63	270.50	228.23

SOURCE: *Highway Statistics 1990.*

[1]1977 Base year = 100

APPENDIX B

BACKGROUND INFORMATION ON RAIL TRANSIT

TABLE B-1
CHARACTERISTICS OF INDIVIDUAL RAIL RAPID TRANSIT SYSTEMS

TRANSIT SYSTEM	OPERATING EMPLOYEE EQUIVALENTS										
	TRANSPORTATION			MAINTENANCE					GENERAL ADMINISTRATION		TOTAL
	ADMIN.	REV. VEH. OPER.	SUPPORT	VEH. MAINT. ADMIN.	REV. VEH. INSPECT. & MAINT.	VEH. MAINT. SUPPORT	NON-VEH. MAINT. ADMIN.	NON-VEH. MAINT. SUPPORT	MKTG. & PLANG.	SUPPORT	
New York CTA	500	4937	1027	1096	2273	1565	1816	6993	100	8233	28539
Chicago-CTA	202	887	1199	184	383	197	0	842	6	307	4208
Washington, D.C.-WMATA	153	358	362	123	525	77	191	1033	89	533	3444
Boston-MBTA	75	602	221	123	220	209	110	504	23	724	2811
San Francisco-BART	226	210	49	34	332	46	28	442	27	440	1834
New York-PATH	40	336	47	19	185	23	90	260	30	150	1180
Philadelphia-SEPTA	74	293	407	76	348	109	74	381	26	210	1997
Atlanta-MARTA	128	150	244	23	116	34	52	146	32	114	1039
Lindenwold-PATCO	13	50	14	7	50	14	17	77	1	88	331
Miami-Dade Cnty TA	33	54	24	26	110	17	26	72	8	118	488
Baltimore-MTA	33	31	49	26	44	14	38	123	4	111	472
Cleveland RTA	13	57	34	10	46	35	5	78	7	62	348
AVERAGE	124	664	306	146	386	195	204	913	29	924	3891
STANDARD DEVIATION	133	1311	385	292	588	418	489	1857	31	2213	7532

(continued)

SOURCE: UMTA Section 15 data for 1989

TABLE B-1 (continued)

TRANSIT SYSTEM	ANNUAL VEHICLE MILES (THOUS)	ANNUAL REVENUE VEHICLE MILES (THOUS)	REVENUE VEHICLE CAPACITY MILES (THOUS)	ANNUAL VEHICLE HOURS (THOUS)	ANNUAL REVENUE VEHICLE HOURS (THOUS)	ANNUAL PASSENGER MILES (THOUS)	TOTAL MILES PER REV. VEH. MILE	REV. VEH. MILES PER REV. VEH. HOUR (MPH)
New York CTA	325690	312195	42458464	18313	17384	7376121	1.04	18.0
Chicago-CTA	55158	54630	4916712	3028	2322	1050922	1.01	23.5
Washington, D.C.-WMATA	34087	32859	7393277	1498	1406	978315	1.04	23.4
Boston-MBTA	22981	21858		1116	1069	480185	1.05	20.4
San Francisco-BART	33873	33195	3817436	1182	1158	757350	1.02	28.7
New York-PATH	14203	13190	2018012	811	628	294983	1.08	21.0
Philadelphia-SEPTA	16542	16276	2115838	1048	1031	415800	1.02	15.8
Atlanta-MARTA	14795	14619	2967741	624	613	359270	1.01	23.8
Lindenwold-PATCO	4192	4096	491479	145	141	96731	1.02	29.0
Miami-Dade Cnty TA	4746	4657	435847	208	195	95450	1.02	23.9
Baltimore-MTA	3685	3530	432919	156	147	66871	1.04	24.1
Cleveland RTA	2137	1952	242009	93	74	58042	1.09	26.4
AVERAGE	44341	42755	6117249	2352	2181	1002503	1.04	23.2
STANDARD DEVIATION	86175	82604	11687346	4876	4627	1949957	0.03	3.8

(continued)

TABLE B-1 (continued)

TRANSIT SYSTEM	VEHICLES OPERATED IN MAX. SERVICE	MAX. VEH. IN AVG. PM PEAK PERIOD	MAX. VEH. IN AVG. BASE PERIOD	PEAK TO BASE RATIO	ACCIDENTS	FATAL-ITIES	INJURIES	GALLONS OF DIESEL FUEL (THOUS)	KILOWATT HOURS (THOUS)
New York CTA	5024	4873	3093	1.58	10909	8	2791	0	1911512
Chicago-CTA	923	903	369	2.45	545	3	786	0	343786
Washington, D.C.-WMATA	576	416	167	2.49	206	1	205	0	295241
Boston-MBTA	449	320	162	1.98	618	0	582	0	148853
San Francisco-BART	346	346	160	2.16	917	0	917	0	172260
New York-PATH	297	297	132	2.25	67	1	66	0	88051
Philadelphia-SEPTA	297	278	166	1.67	318	4	384	0	123043
Atlanta-MARTA	139	134	104	1.29	239	2	238	0	73717
Lindenwold-PATCO	90	90	12	7.50	35	0	35	0	34047
Miami-Dade Cnty TA	70	70	32	2.19	152	0	152	0	43187
Baltimore-MTA	60	60	28	2.14	38	0	76	0	24328
Cleveland RTA	35	33	12	2.75	169	1	128	0	28000
AVERAGE	692	652	370	2.54	1184	2	530	0	273835
STANDARD DEVIATION	1329	1293	827	1.55	2943	2	737	0	503650

(continued)

TABLE B-1 (continued)

TRANSIT SYSTEM	TOTAL OPERATING EXPENSES (THOUS)	PERCENT OF OPERATING EXPENSES BY OBJECT CLASS									
		SALARIES AND WAGES		FRINGE BENEFITS	SERVICES	MATERIALS AND SUPPLIES		UTILITIES	CASUALTY & LIABILITY	PURCH TRAN	OTHER
		OPER-ATORS	OTHER			FUEL & LUB	TIRES & OTHER				
New York CTA	$2,020,103	9.9	41.2	30.9	1.8	0.0	8.3	7.4	0.0	0.0	0.3
Chicago-CTA	$214,474	11.9	37.7	25.3	1.2	0.0	10.5	12.7	0.0	0.0	0.7
Washington, D.C.-WMATA	$228,783	5.5	41.5	23.9	6.2	0.0	7.8	12.8	1.7	0.0	0.6
Boston-MBTA	$201,254	7.8	39.4	32.9	7.7	0.1	6.0	7.7	1.4	0.0	-3.0
San Francisco-BART	$165,320	4.6	43.5	30.6	8.9	0.0	4.7	10.3	2.3	0.0	-4.9
New York-PATH	$119,686	13.8	34.8	19.9	3.3	0.0	4.4	5.3	3.7	0.0	14.9
Philadelphia-SEPTA	$57,301	11.3	48.7	32.1	0.1	0.0	9.9	13.6	0.0	0.0	-15.7
Atlanta-MARTA	$48,459	7.5	33.9	17.1	13.5	0.1	9.2	14.7	3.8	0.0	0.2
Lindenwold-PATCO	$20,133	6.3	35.5	25.4	4.1	0.1	6.2	16.6	4.3	0.0	1.5
Miami-Dade Cnty TA	$38,162	4.0	33.7	19.9	14.1	0.0	5.9	12.6	6.6	0.0	3.1
Baltimore-MTA	$26,531	4.5	46.7	23.5	4.9	0.0	7.7	11.0	1.7	0.0	0.0
Cleveland RTA	$20,163	16.4	34.4	22.3	3.8	0.3	8.0	13.9	0.6	0.0	0.2
AVERAGE	$263,364	8.6	39.3	25.3	5.8	0.1	7.4	11.6	2.2	0.0	-0.2
STANDARD DEVIATION	$535,225	3.9	4.9	5.0	4.3	0.1	1.9	3.2	2.0	0.0	6.5

TABLE B-2
CHARACTERISTICS OF INDIVIDUAL LIGHT RAIL SYSTEMS

TRANSIT SYSTEM	OPERATING EMPLOYEE EQUIVALENTS										
	TRANSPORTATION			MAINTENANCE					GENERAL ADMINISTRATION		TOTAL
	ADMIN.	REV. VEH. OPER.	SUPPORT	VEH. MAINT. ADMIN.	REV. VEH. INSPECT. & MAINT.	VEH. MAINT. SUPPORT	NON-VEH. MAINT. ADMIN.	NON-VEH. MAINT. SUPPORT	MKTG. & PLANG.	SUPPORT	
Philadelphia-SEPTA	67	350	23	33	171	31	73	299	21	166	1235
San Francisco-MUNI	25	219	101	25	213	54	13	80	4	22	756
Pittsburgh-PAT	13	120	34	24	69	33	0	94	5	36	429
Cleveland RTA	8	34	19	6	24	19	3	45	4	35	198
San Diego Trolley	17	45	2	6	19	24	4	15	0	17	148
RTA-New Orleans	3	50	3	5	29	13	3	28	0	2	136
Buffalo-Niag.Front.	8	22	11	6	15	7	16	59	0	21	164
Sacramento RTD	17	31	0	5	11	8	3	9	0	8	92
Newark-NJT Corp	2	21	2	0	23	5	0	0	1	5	59
Portland-MTD	4	32	13	12	13	6	1	24	5	21	130
Santa Clara County TD	18	34	5	10	19	9	5	26	2	20	149
Boston-MBTA	6	61	19	16	37	18	12	86	2	46	303
Seattle Metro	0	3	0	0	3	1	0	2	1	1	11
AVERAGE	15	79	18	11	50	18	10	59	3	31	293
STANDARD DEVIATION	17	95	26	10	63	14	19	76	5	41	330

(continued)

SOURCE: UMTA Section 15 data for 1989

TABLE B-2 (continued)

TRANSIT SYSTEM	ANNUAL VEHICLE MILES (THOUS)	ANNUAL REVENUE VEHICLE MILES (THOUS)	REVENUE VEHICLE CAPACITY MILES (THOUS)	ANNUAL VEHICLE HOURS (THOUS)	ANNUAL REVENUE VEHICLE HOURS (THOUS)	ANNUAL PASSENGER MILES (THOUS)	TOTAL MILES PER REV. VEH. MILE	REV. VEH. MILES PER REV. VEH. HOUR (MPH)
Philadelphia-SEPTA	5046	4832	391354	566	541	104612	1.04	8.9
San Francisco-MUNI	4002	4002	544316	382	382	105475	1.00	10.5
Pittsburgh-PAT	2079	1988	228602	138	132	63503	1.05	15.0
Cleveland RTA	1103	1035	138625	67	44	29099	1.07	23.3
San Diego Trolley		2367	507683	132	126	75937		18.9
RTA-New Orleans	546	545	43602	61	60	8719	1.00	9.0
Buffalo-Niag.Front.	921	919	110208	85	82	19665	1.00	11.2
Sacramento RTD	1084	1060	184459	61	54	21634	1.02	19.8
Newark-NJT Corp	622	622	41055	42	42	8131	1.00	14.8
Portland-MTD	1415	1400	232340	94	73	34957	1.01	19.2
Santa Clara County TD	538	534	89250	43	42	6612	1.01	12.9
Boston-MBTA	1230	1184	131278	82	79	28755	1.04	14.9
Seattle Metro	31	31	1229	6	6	203	1.00	5.0
AVERAGE	1551	1578	203385	135	128	39023	1.02	14.1
STANDARD DEVIATION	1433	1356	168670	153	149	35090	0.02	5.0

(continued)

TABLE B-2 (continued)

TRANSIT SYSTEM	VEHICLES OPERATED IN MAX. SERVICE	MAX. VEH. IN AVG. PM PEAK PERIOD	MAX. VEH. IN AVG. BASE PERIOD	PEAK TO BASE RATIO	ACCIDENTS	FATAL-ITIES	INJURIES	GALLONS OF DIESEL FUEL (THOUS)	KILOWATT HOURS (THOUS)
Philadelphia-SEPTA	176	170	94	1.81	700	0	661	0	63188
San Francisco-MUNI	103	102	62	1.65	252	0	113	0	40503
Pittsburgh-PAT	61	33	14	2.36	82	1	81	0	24828
Cleveland RTA	29	28	7	4.00	122	1	66	0	13726
San Diego Trolley	24				6	0	6	0	11298
RTA-New Orleans	24	24	14	1.71	164	0	69	0	2120
Buffalo-Niag.Front.	23	23	12	1.92	148	0	130	0	9302
Sacramento RTD	23	23	8	2.88	83	0	60	0	6899
Newark-NJT Corp	22	16	7	2.29	50	0	47	0	2470
Portland-MTD	22	22	15	1.47	204	1	210	0	8615
Santa Clara County TD	16	8	9	0.89	44	1	28	0	7411
Boston-MBTA	6	135	68	1.99	439	1	195	0	49543
Seattle Metro	2	2	2	1.00	1	0	0	0	125
AVERAGE	41	49	26	2.00	177	0	128	0	18464
STANDARD DEVIATION	46	53	29	0.80	189	0	166	0	19340

(continued)

TABLE B-2 (continued)

TRANSIT SYSTEM	TOTAL OPERATING EXPENSES (THOUS)	PERCENT OF OPERATING EXPENSES BY OBJECT CLASS									
		SALARIES AND WAGES		FRINGE BENEFITS	SERVICES	MATERIALS AND SUPPLIES		UTILITIES	CASUALTY & LIABILITY	PURCH TRAN	OTHER
		OPER-ATORS	OTHER			FUEL & LUB	TIRES & OTHER				
Philadelphia-SEPTA	$33,706	28.9	26.1	29.4	0.1	0.0	11.6	11.9	0.0	0.0	-7.9
San Francisco-MUNI	$33,634	23.4	37.0	30.0	0.0	0.0	4.6	3.5	0.0	0.0	1.5
Pittsburgh-PAT	$20,697	16.6	44.4	24.6	1.7	0.2	7.3	11.7	2.0	0.0	-8.6
Cleveland RTA	$10,664	13.2	37.3	22.2	4.1	0.3	8.7	13.1	0.8	0.0	0.2
San Diego Trolley	$9,159	15.3	27.8	8.0	14.4	0.1	5.8	13.0	8.5	0.0	7.1
RTA-New Orleans	$1,817	33.9	21.2	22.4	0.0	0.6	6.2	15.8	0.0	0.0	0.0
Buffalo-Niag.Front.	$11,141	5.4	32.3	19.2	23.0	0.2	7.9	9.7	2.3	0.0	0.1
Sacramento RTD	$5,595	12.5	36.8	27.5	4.7	0.0	2.6	15.9	0.0	0.0	0.0
Newark-NJT Corp	$3,328	19.4	33.7	25.8	1.7	9.3	6.6	3.4	0.0	0.0	0.1
Portland-MTD	$5,953	17.5	33.9	23.9	1.3	0.4	9.6	12.2	0.2	0.0	1.0
Santa Clara County TD	$9,944	9.8	38.9	25.5	9.7	0.1	0.9	7.2	6.2	0.0	1.7
Boston-MBTA	$20,718	8.4	36.0	31.4	3.5	0.1	6.4	8.3	7.9	0.0	-1.9
Seattle Metro	$450	19.4	33.4	18.9	14.6	0.1	17.4	1.6	0.0	0.0	-5.3
AVERAGE	$12,831	17.2	33.8	23.8	6.1	0.9	7.4	9.8	2.1	0.0	-0.9
STANDARD DEVIATION	$10,693	7.7	5.8	5.9	6.9	2.4	4.0	4.5	3.1	0.0	4.1

TABLE B-3
CHARACTERISTICS OF INDIVIDUAL COMMUTER RAIL SYSTEMS

TRANSIT SYSTEM	OPERATING EMPLOYEE EQUIVALENTS										
	TRANSPORTATION			MAINTENANCE					GENERAL ADMINISTRATION		TOTAL
	ADMIN.	REV. VEH. OPER.	SUPPORT	VEH. MAINT. ADMIN.	REV. VEH. INSPECT. & MAINT.	VEH. MAINT. SUPPORT	NON-VEH. MAINT. ADMIN.	NON-VEH. MAINT. SUPPORT	MKTG. & PLANG.	SUPPORT	
New York-LIRR	130	1131	282	229	1088	329	355	911	65	798	5318
New York-MTNR	57	799	484	113	1150	46	75	1147	44	1140	5054
Newark-NJT Corp	63	847	471	116	905	48	18	627	33	368	3496
Chicago-Commuter Rail Bd	17	426	334	15	458	53	76	292	23	317	2011
Chicago & NW Tr Co	15	242	121	36	307	33	10	186	22	26	998
Philadelphia-SEPTA	66	472	169	69	354	66	46	313	25	216	1797
Boston-Amtrak/MBTA	16	375	253	10	291	3	17	3	0	9	977
Chicago-Burlington No.	3	113	41	11	93	38	10	38	0	48	395
San Francisco-Caltrans	4	122	53	3	48	66	15	0	0	3	314
Staten Island Rap.Tr.	8	96	21	4	6	32	7	105	3	46	328
AVERAGE	38	462	223	61	470	71	63	362	21	297	2069
STANDARD DEVIATION	39	337	162	70	405	88	101	382	21	366	1812

(continued)

SOURCE: UMTA Section 15 data for 1989

TABLE B-3 (continued)

TRANSIT SYSTEM	ANNUAL VEHICLE MILES (THOUS)	ANNUAL REVENUE VEHICLE MILES (THOUS)	REVENUE VEHICLE CAPACITY MILES (THOUS)	ANNUAL VEHICLE HOURS (THOUS)	ANNUAL REVENUE VEHICLE HOURS (THOUS)	ANNUAL PASSENGER MILES (THOUS)	TOTAL MILES PER REV. VEH. MILE	REV. VEH. MILES PER REV. VEH. HOUR (MPH)
New York-LIRR	65380	57062	9700487	2160	1914	2117068	1.15	29.8
New York-MTNR	39993	35045	3937610	1116	960	1535405	1.14	36.5
Newark-NJT Corp	37135	34180	4370868	1210	1120	997596	1.09	30.5
Chicago-Commuter Rail Bd	12463	11482	1768027	397	371	612716	1.09.	31.0
Chicago & NW Tr Co	11970	11499	1839764	358	350	514791	1.04	32.8
Philadelphia-SEPTA	12203	11555	1860292	447	419	361883	1.06	27.6
Boston-Amtrak/MBTA	13211	13211	1519305	429	429	330134	1.00	30.8
Chicago-Burlington No.	4580	3961	574324	133	114	260020	1.16	34.7
San Francisco-Caltrans	2458	2457	356939	76	76	131075	1.00	32.5
Staten Island Rap.Tr.	2249	2089	365611	108	99	42938	1.08	21.2
AVERAGE	20164	18254	2629323	643	585	690363	1.08	30.7
STANDARD DEVIATION	19599	17084	2691577	628	554	635268	0.05	4.0

(continued)

TABLE B-3 (continued)

TRANSIT SYSTEM	VEHICLES OPERATED IN MAX. SERVICE	MAX. VEH. IN AVG. PM PEAK PERIOD	MAX. VEH. IN AVG. BASE PERIOD	PEAK TO BASE RATIO	ACCIDENTS	FATAL-ITIES	INJURIES	GALLONS OF DIESEL FUEL (THOUS)	KILOWATT HOURS (THOUS)
New York-LIRR	1040	962	470	2.05	341	28	301	6707	453254
New York-MTNR	664	580			749	0	719	4077	344290
Newark-NJT Corp	613				2372	29	1821	10445	84270
Chicago-Commuter Rail Bd	391	356	116	3.07	315	5	379	6485	78395
Chicago & NW Tr Co	331	289	82	3.52	0	0	0	8823	0
Philadelphia-SEPTA	275	252	64	3.94	240	0	261	0	189109
Boston-Amtrak/MBTA	245				0	0	0	7473	0
Chicago-Burlington No.	163	137	19	7.21	0	0	0	3568	0
San Francisco-Caltrans	67	55	41	1.34	15	3	7	2428	0
Staten Island Rap.Tr.	36	36	16	2.25	69	0	59	0	18807
AVERAGE	383	333	115	3.34	410	7	355	5001	116813
STANDARD DEVIATION	294	289	148	1.78	692	11	537	3391	153911

(continued)

TABLE B-3 (continued)

TRANSIT SYSTEM	TOTAL OPERATING EXPENSES (THOUS)	PERCENT OF OPERATING EXPENSES BY OBJECT CLASS									
		SALARIES AND WAGES		FRINGE BENEFITS	SERVICES	MATERIALS AND SUPPLIES		UTILITIES	CASUALTY & LIABILITY	PURCH TRAN	OTHER
		OPER-ATORS	OTHER			FUEL & LUB	TIRES & OTHER				
New York-LIRR	$593,457	9.9	32.6	43.0	3.9	0.9	7.9	6.4	3.2	0.0	-7.7
New York-MTNR	$401,765	9.7	34.4	25.5	6.5	0.9	9.0	7.1	6.0	0.0	0.8
Newark-NJT Corp	$262,827	11.6	26.3	21.5	10.2	2.5	11.3	7.7	5.0	3.5	0.5
Chicago-Commuter Rail Bd	$268,563	6.3	16.6	14.7	4.8	1.3	3.6	3.5	1.9	48.8	-1.5
Chicago & NW Tr Co	$86,245	13.7	28.9	24.0	1.2	5.7	4.0	0.0	3.6	0.0	18.9
Philadelphia-SEPTA	$97,658	17.6	31.1	26.1	11.7	0.2	16.6	16.5	-2.9	0.0	-16.9
Boston-Amtrak/MBTA	$78,399	24.2	29.0	21.3	0.0	6.9	9.7	0.0	1.5	0.0	7.3
Chicago-Burlington No.	$32,940	16.2	26.2	18.0	1.8	6.0	9.9	0.1	6.9	0.0	15.0
San Francisco-Caltrans	$19,746	11.8	54.0	20.0	0.7	6.6	2.8	0.0	3.1	0.0	0.9
Staten Island Rap.Tr.	$17,566	18.2	44.0	28.6	0.0	0.0	11.7	8.0	0.0	0.0	-10.6
AVERAGE	$185,917	13.9	32.3	24.3	4.1	3.1	8.7	4.9	2.8	5.2	0.7
STANDARD DEVIATION	$182,775	4.9	9.8	7.3	4.0	2.7	4.1	5.1	2.7	14.6	10.5

TABLE B-4
CHARACTERISTICS OF RECENTLY CONSTRUCTED LIGHT RAIL SYSTEMS

	Portland	Sacramento	San Jose	Pittsburgh	Los Angeles
Opening Year	1986	1987	1987[1]	1988	1990[2]
Route Length (miles)					
At-Grade	9.9	17.6	19.7	27.1	18.3
Elevated	5.2	0.7	0.2	2.9	3.6
Subway	0.0	0.0	0.0	5.3	0.6
Open Cut	0.2	0.0	0.0	5.8	0.1
Total	15.2	18.3	19.9	41.1	22.6
Track Miles	29.3	25.6	40.8	62.4[3]	43.6
Stations	25	26	22	13	22
Parking Lots	5	8	NR[4]	NR	5
Parking Spaces	1636	3850	NR	NR	1051

(continued)

[1]North Line

[2]Metro Blue Line

[3]Total system statistics; not project-specific.

[4]Not Reported

TABLE B-4 (continued)

	Portland	Sacramento	San Jose	Pittsburgh	Los Angeles
Total Revenue Vehicles	26	26	50	97	54
Peak Period Vehicles	22	23	15	70	26
Midday Vehicles	12	8	15	28	13
Peak Headway (minutes)	7.5	15	10	NR	10
Midday Headways (minutes)	15	30	10	NR	10
Staff					
Administrative	16	15	11	NR	28
Operators	36	32	58	112	73
Vehicle Maintenance	28	15	55	NR	47
Facility Maintenance	19	16	53	NR	45
Other	11	5	20	NR	68
Total	110	83	197	503	261

Source: Booz-Allen & Hamilton Inc.; Light Rail Transit Capital Cost Study; prepared for Urban Mass Transportation Administration, Office of Technical Assistance and Safety; April 5, 1991.

TABLE B-5
OBSERVED PEAK-HOUR PASSENGER VOLUMES ON RAPID TRANSIT SYSTEMS

CITY AND YEAR		LINE/LOCATION	TRAINS PER HOUR	CARS PER HOUR	HEADWAY SECONDS	APPROX. CAR LENGTH FT (ROUNDED)	PERSONS/ HOUR IN PEAK DIRECTION (MAX. LOAD SECTION)	PASSENGERS PER TRAIN (ROUNDED)
New York City	1982	IND E, F, 53rd St. Tunnel	26	208	128	75	54,500	2,100
		IND A, D, 8th Ave Express	21	210	159	60, 75	43,500	2,070
		IRT 4, 5, Lexington Ave. Exp.	25	250	157	50	38,100	1,520
		PATH-World Trade Center[a]	38	266	98	50	25,500	670
	1960	IND E, F, 53rd St. Tunnel	32	320	112	60	61,400	1,920
		IND A, D, 8th Ave. Express	30	300	120	60	62,000	2,070
		IND 4, 5, Lexington Ave. Exp.	31	310	116	50	44,500	1,430
		IND 2, 3, 7th Ave. Express	24	240	150	50	36,800	1,530
Toronto	1978	Yonge St.	30	210	120	75	32,000	1,060
	1974	Yonge St.	28	168	129	75	36,000	1,290
	1960	Yonge St.	28	224	129	57	32,200	1,260
Montreal	1976	N Line	23	207	157	56	28,200	940
Chicago	1984	Milwaukee	17	136	212	50	12,400	730
		Lake-Ryan	19	152	189	50	12,300	647
		North-South	15	120	240	50	11,400	760
	1978	Lake-Ryan	21	168	111	50	16,500	790
		North-South	20	160	180	50	14,000	700
Philadelphia	1976	North Broad (2 tracks)	23	126	157	67	10,600	460
Boston	1977–78	Red Line	17	68	212	70	13,000	460
		Orange Line	13	52	277	55	8,400	650
San Francisco	1977	BART-Transbay	11	98	327	75	8,000	730
		BART-Mission	10	85	360	75	6,500	650
Washington	1980	Blue-Orange	20	120	180	75	13,000	650
Atlanta	1980	East Line	6	36	600	75	4,250	710
Cleveland	1976	West Side	14	52	258	50, 70	5,400	390
	1960	West Side	20	80	180	50	6,200	360

[a] Multiple track terminal.

SOURCE: 1985 *Highway Capacity Manual*

TABLE B-6
OBSERVED PEAK-HOUR PASSENGER VOLUMES ON STREET CAR AND LIGHT RAIL SYSTEMS

CITY	LOCATION	YEAR	TRAINS PER HOUR	CARS PER HOUR	HEADWAY SECONDS	LENGTH OF CAR OR TRAIN	PASSENGER/HOUR IN PEAK DIRECTION	PASSENGER/CAR OR TRAIN	EQUIPMENT
ON STREET									
Pittsburgh	Smithfield St. Bridge	1949	120	120	30	46.5	9,000[a]	75[a]	PCC
Pittsburgh	Smithfield St.	1976	51	51	71	46.5	3,800	74	PCC
San Francisco	Market Street (before subway)	1977	68	68	53	46.0	4,900	72	PCC
Toronto	Queen St. East	1978	66	66	55	46.5	4,200	64	PCC
IN TUNNEL OR OFF STREET									
Philadelphia	Market St.	1956	133	133	27	46.0	9,000	67	PCC
Boston	Green Line (Boylston St.)	1976	36	88	100	46.5	6,900	192	PCC
Philadelphia	Market Street	1978	73	73	180	46.0	3,700	151	PCC
San Francisco	Market Street	1983	NA	62	NA	70.0	6,340	109	Boeing LRV
Cleveland	Shaker Hts.	1976	30[a]	60[a]	120[a]	50.0	4,400	143	PCC
Boston	Green Line (Lechmere)	1978	16	48	225	46.5	1,500	94	PCC
Newark	City Subway	1978	30	30	120	46.5	1,500	50	PCC
Edmonton	LRT Line	1978	12	24	300	77.0	2,100	87	DUWAG
San Diego	LRT	1981	3	6	1,200	151	600	200	DUWAG

[a] Estimated.

SOURCE: 1985 *Highway Capacity Manual*

TABLE B-7
RAPID TRANSIT TRAIN AND CAR CAPACITIES

		LENGTH (FT)	WIDTH (FT)	AREA (FT^2)	SEATED PASSENGERS	TOTAL PASSENGERS		MAXIMUM CARS/TRAIN	SEATED PASSENGERS/ TRAIN
						SCHEDULE	CRUSH		
New York City Transit Authority	IRT	51.33	8.79	451.2	44	140	180	10–11	440–484
	IND	60.50	10.0	605	50	180	220	10	500
	R-44 R-46	75.00	10.0	750.0	72–76	225	225 290	8	576–608
Port Authority of N.Y. and N.J. (PATH)		51.25	9	473.0	42	140	200	7	294
Chicago Transit Authority		48.25	9.33	450.1	c.50	125	135	8	400
Philadelphia (SEPTA)									
Broad St.		67.50	10.00	675.0	67	NA	281 (est.)	6	450
Market St.		55.33	9.08	502.4	55	115	200	8 (est.)	440
Massachusetts Bay Transportation Authority									
Blue Line		48.75	8.58	418.3	48	125	191	4	192
Orange Line		55.31	9.28	513.3	54	175	240	4	216
Red Line		69.81	10.35	722.5	63	208	275	4	252
New Jersey (PATCO)		67.83	10.12	686.4	80	100	200	8	640
Toronto Transit Commission									
1962–1975		74.76	10.33	772.3	84	230	310	6	504
1953–1958		57.00	10.33	588.8	62	174	233	8	496
Bay Area Rapid Transit		75.00	10.5	787.5	72	144	216	8	576
Montreal Urban Community Transit Commission		56.42	8.25	465.5	39	157	208	29	351
Greater Cleveland Regional Transit Authority									
Airporter		70.25	10.41	731.3	80	120	140	4	320
Other		48.75	10.33	403.6	54	100	197	6	324
Washington Metropolitan Area Transit Authority		75.00	10.15	761.2	80	175	240	6	480

TABLE B-7 (continued)

		TOTAL PASSENGERS/ TRAIN		SEATED PASSENGERS/ FOOT OF LENGTH	TOTAL PASSENGERS/ FOOT OF LENGTH		FT^2/ SEATED PASSENGERS	FT^2/TOTAL PASSENGERS	
		DESIGN	CRUSH		SCHEDULE	CRUSH		SCHEDULE	CRUSH
New York City Transit Authority	IRT	1,400	1,800	0.86	2.72	3.51	10.2	3.22	2.50
	IND	1,800	2,200	0.83	2.97	3.64	12.1	3.36	2.75
	R-44 R-46	1,800	2,240	0.96-1.01	3.00	3.73	9.9-10.1	3.33	2.67
Port Authority of N.Y. and N.J. (PATH)		980	1,400	0.82	2.73	3.90	11.3	3.37	2.36
Chicago Transit Authority		1,000	1,480	1.03	2.59	3.83	9.0	3.60	2.43
Philadelphia (SEPTA)									
Broad St.		NA	1,686	0.99	NA	4.16	10.1	NA	2.40
Market St.		920	1,600	0.99	2.07	3.61	9.1	4.37	2.51
Massachusetts Bay Transportation Authority									
Blue Line		500	764	0.98	2.56	3.91	8.7	3.34	2.19
Orange Line		700	960	0.98	3.16	4.34	9.5	2.93	2.14
Red Line		832	1,100	0.90	2.98	3.94	11.4	3.47	2.62
New Jersey (PATCO)		800	1,600	1.01	1.47	2.95	8.6	6.68	3.43
Toronto Transit Commission									
1962-1975		1,380	1,860	1.12	3.08	4.14	9.2	3.36	2.49
1953-1958		1,392	1,864	1.09	3.05	4.09	9.5	3.38	2.52
Bay Area Rapid Transit		1,152	1,728	0.96	1.92	2.88	10.9	5.47	3.64
Montreal Urban Community Transit Commission		1,413	1,872	0.69	2.78	3.69	11.9	2.96	2.23
Greater Cleveland Regional Transit Authority									
Airporter		480	560	1.14	1.71	1.99	9.1	6.09	5.22
Other		600	1,182	1.11	2.05	4.04	9.3	5.04	2.55
Washington Metropolitan Area Transit Authority		1,050	1,440	1.07	2.33	3.20	9.52	4.35	3.17

SOURCE: Computed by Herbert S. Levinson from data obtained from Roster of North American Rapid Transit Cars 1945-1976, American Public Transit Association. Schedule and crush load data are based on information received from APTA.

APPENDIX C

BACKGROUND INFORMATION ON BUS TRANSIT

TABLE C-1
CHARACTERISTICS OF INDIVIDUAL BUS SYSTEMS WITH 500 OR MORE BUSES

TRANSIT SYSTEM	OPERATING EMPLOYEE EQUIVALENTS										
	TRANSPORTATION			MAINTENANCE					GENERAL ADMINISTRATION		TOTAL
	ADMIN.	REV. VEH. OPER.	SUPPORT	VEH. MAINT. ADMIN.	REV. VEH. INSPECT. & MAINT.	VEH. MAINT. SUPPORT	NON-VEH. MAINT. ADMIN.	NON-VEH. MAINT. SUPPORT	MKTG. & PLANG.	SUPPORT	
New York CTA	741	8015	225	821	2082	712	8	475	55	1711	14843
Los Angeles-SCRTD	367	4439	134	187	1033	423	15	253	163	693	7707
Chicago-CTA	385	4085	386	207	769	474	0	384	7	360	7057
Newark-NJT Corp	178	2524	196	54	628	274	0	78	50	549	4530
Washington, D.C.-WMATA	131	2518	101	107	653	148	44	138	156	415	4410
Philadelphia-SEPTA	198	2411	55	104	599	127	18	87	45	392	4037
Minneapolis MTC	212	1125	69	16	313	42	2	50	48	175	2051
Seattle Metro	83	1376	122	129	181	99	30	115	119	228	2482
Boston-MBTA	73	1233	177	110	302	77	6	149	26	325	2478
Pittsburgh-PAT	46	1374	127	63	334	174	0	196	37	235	2586
Baltimore-MTA	55	1131	93	41	259	95	14	63	55	165	1971
Houston-MTA	34	1149	117	112	346	143	7	85	76	523	2591
Alameda-Contra Costa	81	1185	66	37	210	81	2	37	39	152	1890
Denver-RTD	33	1005	101	33	207	118	27	64	65	229	1882
St Louis-Bi-State	45	942	25	36	188	102	28	69	61	154	1648
Cleveland RTA	66	877	70	17	245	116	8	70	36	302	1806
Atlanta-MARTA	81	1393	99	27	331	120	26	35	9	262	2383
Dallas Area Rapid Transit	44	770	42	71	259	79	8	62	104	285	1724

(continued)

SOURCE: UMTA Section 15 data for 1989

TABLE C-1 (continued)

TRANSIT SYSTEM	ANNUAL VEHICLE MILES (THOUS)	ANNUAL REVENUE VEHICLE MILES (THOUS)	REVENUE VEHICLE CAPACITY MILES (THOUS)	ANNUAL VEHICLE HOURS (THOUS)	ANNUAL REVENUE VEHICLE HOURS (THOUS)	ANNUAL PASSENGER MILES (THOUS)	TOTAL MILES PER REV. VEH. MILE	REV. VEH. MILES PER REV. VEH. HOUR (MPH)
New York CTA	104039	94676	6627309	12829	11989	1514915	1.10	7.9
Los Angeles-SCRTD	101115	86150	5851000	7464	6862	1648700	1.17	12.6
Chicago-CTA	74285	72799	5532687	7396	7247	1034122	1.02	10.0
Newark-NJT Corp	73171	60958	4018495	4841	3315	911149	1.20	18.4
Washington, D.C.-WMATA	49008	39350	2636460	3995	2861	530499	1.25	13.8
Philadelphia-SEPTA	39832	35151	2144212	3930	3486	491684	1.13	10.1
Minneapolis MTC	27615	21260	1967242	1996	1537	267559	1.30	13.8
Seattle Metro	31781	23349	1914617	2044	1406	348581	1.36	16.6
Boston-MBTA	26180	23240	1505896	2182	1959	232548	1.13	11.9
Pittsburgh-PAT	30872	26821	1770196	2250	1955	316721	1.15	13.7
Baltimore-MTA	24443	20812	1173880	2186	1929	309679	1.17	10.8
Houston-MTA	34794	27753	1740134	2233	1883	437402	1.25	14.7
Alameda-Contra Costa	24992	21954	1496191	1900	1708	275408	1.14	12.9
Denver-RTD	26424	22347	1454413	1733	1290	199205	1.18	17.3
St Louis-Bi-State	24475	18652	1182276	1729	1280	174844	1.31	14.6
Cleveland RTA	23019	19769	1516246	1763	1300	179055	1.16	15.2
Atlanta-MARTA	29133	25362	1826084	2139	1959	271371	1.15	12.9
Dallas Area Rapid Tr	19982	16509	1139131	1358	1192	168434	1.21	13.8

(continued)

TABLE C-1 (continued)

TRANSIT SYSTEM	VEHICLES OPERATED IN MAX. SERVICE	MAX. VEH. IN AVG. PM PEAK PERIOD	MAX. VEH. IN AVG. BASE PERIOD	PEAK TO BASE RATIO	ACCIDENTS	FATAL-ITIES	INJURIES	GALLONS OF FUEL (THOUS)
New York CTA	3103	2873	1874	1.53	4921	27	6968	34456
Los Angeles-SCRTD	1939	1826	1253	1.46	5223	9	4351	27980
Chicago-CTA	1803	1786	986	1.81	5227	8	6222	24272
Newark-NJT Corp	1648	1460	683	2.14	5112	6	1483	19034
Washington, D.C.-WMATA	1400	1331	473	2.81	2344	4	907	16433
Philadelphia-SEPTA	1169	1058	584	1.81	2779	3	2809	14247
Minneapolis MTC	833	821	271	3.03	2135	5	1149	7063
Seattle Metro	832	832	279	2.98	1427	1	241	7750
Boston-MBTA	814	693	314	2.21	2044	1	671	7184
Pittsburgh-PAT	776	664	348	1.91	1813	2	919	10246
Baltimore-MTA	734	654	259	2.53	2055	7	3767	7539
Houston-MTA	718	690	300	2.30				9985
Alameda-Contra Costa	653	604	304	1.99	1136	5	309	7609
Denver-RTD	603	565	273	2.07	1083	1	610	6707
St Louis-Bi-State	598	553	278	1.99	715	1	514	6534
Cleveland RTA	578	572	275	2.08	2945	0	1216	5997
Atlanta-MARTA	566	565	266	2.12	714	0	137	8822
Dallas Area Rapid Tr	524	509	185	2.75	1007	3	937	6420

TABLE C-1 (continued)

TRANSIT SYSTEM	TOTAL OPERATING EXPENSES (THOUS)	PERCENT OF OPERATING EXPENSES BY OBJECT CLASS									
		SALARIES AND WAGES		FRINGE BENEFITS	SERVICES	MATERIALS AND SUPPLIES		UTILITIES	CASUALTY & LIABILITY	PURCH TRAN	OTHER
		OPER-ATORS	OTHER			FUEL & LUB	TIRES & OTHER				
New York CTA	$905,562	29.6	24.6	32.7	2.5	2.7	5.9	0.2	1.6	0.0	0.1
Los Angeles-SCRTD	$520,889	25.4	23.9	30.3	4.4	3.3	6.7	1.1	6.4	0.0	-1.6
Chicago-CTA	$332,476	36.2	19.7	28.5	3.5	4.3	7.5	0.0	-0.1	0.0	0.4
Newark-NJT Corp	$300,854	25.4	19.2	21.4	3.6	3.5	7.2	1.6	5.1	10.8	2.3
Washington, D.C.-WMATA	$280,681	27.7	20.7	29.7	2.4	3.4	10.2	1.0	4.2	0.0	0.8
Philadelphia-SEPTA	$133,011	39.5	18.2	30.9	0.2	5.6	13.2	0.1	0.1	0.0	-7.7
Minneapolis MTC	$103,363	33.3	21.8	26.8	2.5	5.1	5.7	1.6	2.0	0.2	0.8
Seattle Metro	$91,493	39.8	15.1	22.6	1.3	5.2	12.6	0.9	-0.2	2.4	0.2
Boston-MBTA	$159,778	22.2	25.6	32.9	3.3	3.0	4.3	3.1	5.4	2.2	-2.0
Pittsburgh-PAT	$95,533	39.9	19.1	23.7	0.4	6.2	9.4	1.0	2.5	0.0	-2.3
Baltimore-MTA	$87,491	39.1	19.3	26.8	0.2	5.0	7.4	0.0	0.0	2.2	0.0
Houston-MTA	$113,553	29.1	36.6	12.3	7.9	4.8	9.6	2.5	0.1	4.9	-7.7
Alameda-Contra Costa	$119,878	30.5	20.6	28.6	5.4	3.2	6.2	1.7	2.0	0.1	1.6
Denver-RTD	$102,055	25.9	24.6	22.7	5.8	3.8	9.1	2.5	1.6	4.0	0.0
St Louis-Bi-State	$63,301	38.4	18.3	24.3	0.7	5.5	10.4	1.9	0.0	0.0	0.4
Cleveland RTA	$97,957	25.3	26.6	22.8	3.9	3.8	6.3	1.9	1.9	6.2	1.3
Atlanta-MARTA	$82,275	36.7	17.8	22.8	2.2	5.8	10.7	0.9	1.1	0.9	1.1
Dallas Area Rapid Tr	$107,081	18.3	19.4	22.4	4.0	3.4	5.9	1.3	1.4	21.9	2.0

(continued)

TABLE C-2
CHARACTERISTICS OF INDIVIDUAL BUS SYSTEMS WITH 250-499 BUSES

TRANSIT SYSTEM	OPERATING EMPLOYEE EQUIVALENTS										
	TRANSPORTATION			MAINTENANCE					GENERAL ADMINISTRATION		TOTAL
	ADMIN.	REV. VEH. OPER.	SUPPORT	VEH. MAINT. ADMIN.	REV. VEH. INSPECT. & MAINT.	VEH. MAINT. SUPPORT	NON-VEH. MAINT. ADMIN.	NON-VEH. MAINT. SUPPORT	MKTG. & PLANG.	SUPPORT	
San Antonio-VIA Metro Tr	42	660	36	16	116	35	1	49	37	78	1069
City of Detroit	13	975	119	49	399	68	6	73	37	131	1870
Milwaukee County TS	84	788	70	57	147	48	2	39	22	87	1343
Portland-Tri-County	53	796	71	28	143	72	1	19	27	116	1326
Santa Clara County TD	52	868	47	60	227	74	4	22	45	81	1481
Miami-Dade Cnty TA	62	964	71	76	177	78	13	33	39	144	1655
Honolulu DOT Service	20	596	37	24	149	60	2	1	25	59	971
RTA-New Orleans	36	607	32	24	155	70	4	16	22	111	1077
S.F.MUNI Motor Bus	41	849	67	34	229	73	6	47	14	82	1442
Buffalo-Niagara Front.	35	510	38	38	139	50	5	28	10	41	893
Orange County TD	65	712	39	46	112	61	4	15	58	186	1298
Salt Lake City-Utah	45	425	5	31	94	39	0	14	38	53	743
Cincinnati-SORTA	12	443	27	21	136	25	2	26	30	32	754
Columbus-Central Ohio TA	11	399	28	12	59	45	3	29	24	63	672
East Meadow-MSBA	46	451	39	31	94	53	0	12	15	96	836
Phoenix Transit System	35	491	23	18	77	43	2	23	36	63	811

(continued)

SOURCE: UMTA Section 15 data for 1989

TABLE C-2 (continued)

TRANSIT SYSTEM	ANNUAL VEHICLE MILES (THOUS)	ANNUAL REVENUE VEHICLE MILES (THOUS)	REVENUE VEHICLE CAPACITY MILES (THOUS)	ANNUAL VEHICLE HOURS (THOUS)	ANNUAL REVENUE VEHICLE HOURS (THOUS)	ANNUAL PASSENGER MILES (THOUS)	TOTAL MILES PER REV. VEH. MILE	REV. VEH. MILES PER REV. VEH. HOUR (MPH)
San Antonio-VIA Metro Tr	17962	16609	798575	1245	1197	152321	1.08	13.9
City of Detroit	24759	22404	1344253	1915	1821	265673	1.11	12.3
Milwaukee County TS	18649	17098	1236364	1528	1456	190388	1.09	11.7
Portland-Tri-County	21003	18197	1294421	1498	1125	159700	1.15	16.2
Santa Clara County TD	22743	19373	1317353	1514	1377	140541	1.17	14.1
Miami-Dade Cnty TA	20886	18474	1043090	1618	1520	214933	1.13	12.2
Honolulu DOT Service	16986	14841	1078358	1142	1054	322870	1.14	14.1
RTA-New Orleans	13049	12077	736679	1197	1106	170883	1.08	10.9
S.F.MUNI Motor Bus	14706	12703	937465	1474	1366	209556	1.16	9.3
Buffalo-Niagara Front.	9946	9774	801460	874	872	65466	1.02	11.2
Orange County TD	17998	15576	1169671	1256	1164	167430	1.16	13.4
Salt Lake City-Utah	14324	12838	577276	863	672	108745	1.12	19.1
Cincinnati-SORTA	11376	9678	600017	831	718	125204	1.18	13.5
Columbus-Central Ohio TA	9046	7491	408818	650	580	82789	1.21	12.9
East Meadow-MSBA	10719	9176	770762	827	627	151010	1.17	14.6
Phoenix Transit System	10688	9445	772228	755	661	98085	1.13	14.3

(continued)

TABLE C-2 (continued)

TRANSIT SYSTEM	VEHICLES OPERATED IN MAX. SERVICE	MAX. VEH. IN AVG. PM PEAK PERIOD	MAX. VEH. IN AVG. BASE PERIOD	PEAK TO BASE RATIO	ACCIDENTS	FATAL-ITIES	INJURIES	GALLONS OF FUEL (THOUS)
San Antonio-VIA Metro Tr	462	443	198	2.24	690	1	296	4830
City of Detroit	457	457	291	1.57	1832	0	417	7268
Milwaukee County TS	452	415	241	1.72	1246	1	1204	5397
Portland-Tri-County	420	417	244	1.71	865	2	831	5052
Santa Clara County TD	417	417	260	1.60	719	2	228	5101
Miami-Dade Cnty TA	413	413	311	1.33	1236	0	592	6045
Honolulu DOT Service	405	383	187	2.05	1193	1	595	5055
RTA-New Orleans	379	373	125	2.98	733	1	912	4190
S.F.MUNI Motor Bus	373	372	239	1.56	1387	1	479	5204
Buffalo-Niagara Front.	361	347	102	3.40	747	0	315	2847
Orange County TD	331	329	257	1.28	792	4	523	5144
Salt Lake City-Utah	324	300	252	1.19	675	1	152	3411
Cincinnati-SORTA	321	252	127	1.98	655	0	150	3208
Columbus-Central Ohio TA	273	257	125	2.06	368	0	184	2270
East Meadow-MSBA	265	259	143	1.81	473	0	123	3225
Phoenix Transit System	264	264	177	1.49	466	2	161	3385

TABLE C-2 (continued)

TRANSIT SYSTEM	TOTAL OPERATING EXPENSES (THOUS)	PERCENT OF OPERATING EXPENSES BY OBJECT CLASS									
		SALARIES AND WAGES		FRINGE BENEFITS	SERVICES	MATERIALS AND SUPPLIES		UTILITIES	CASUALTY & LIABILITY	PURCH TRAN	OTHER
		OPER-ATORS	OTHER			FUEL & LUB	TIRES & OTHER				
San Antonio-VIA Metro Tr	$36,691	40.5	18.5	19.2	0.8	6.6	9.8	0.0	1.7	0.0	3.0
City of Detroit	$132,258	19.7	16.2	30.2	9.7	3.5	9.6	2.0	8.9	0.0	0.2
Milwaukee County TS	$67,865	33.5	20.5	29.6	3.7	4.0	5.9	1.7	0.4	0.0	0.8
Portland-Tri-County	$59,977	39.8	16.8	26.3	1.1	4.8	8.8	1.3	0.8	0.2	0.2
Santa Clara County TD	$102,769	27.7	22.4	26.5	9.1	3.3	6.6	0.8	2.7	0.0	0.8
Miami-Dade Cnty TA	$97,789	29.3	23.7	24.4	5.2	3.5	5.8	0.4	2.1	4.4	1.2
Honolulu DOT Service	$64,666	29.0	17.3	24.5	4.6	5.1	9.8	0.4	4.0	0.0	5.5
RTA-New Orleans	$41,788	35.2	22.0	23.2	0.0	6.6	7.9	0.0	0.0	3.3	1.8
S.F.MUNI Motor Bus	$66,621	42.1	15.0	27.1	1.4	5.1	8.5	0.3	0.0	0.0	0.5
Buffalo-Niagara Front.	$39,199	32.7	21.5	31.2	0.8	4.0	6.2	1.9	1.4	0.0	0.4
Orange County TD	$77,283	26.9	22.3	23.2	4.7	3.7	8.3	1.6	1.9	6.1	1.3
Salt Lake City-Utah	$32,103	29.2	24.0	20.3	5.4	7.0	8.6	2.0	1.2	0.0	2.4
Cincinnati-SORTA	$40,672	28.9	21.3	28.8	3.7	4.6	6.8	1.9	1.0	0.9	2.1
Columbus-Central Ohio TA	$33,809	32.2	21.0	30.2	4.3	4.4	4.9	0.0	0.9	0.0	2.1
East Meadow-MSBA	$53,193	28.9	23.9	25.6	4.2	4.4	6.7	2.2	3.6	0.0	0.4
Phoenix Transit System	$36,914	29.8	20.3	18.9	7.0	6.2	11.0	1.2	2.9	0.0	2.7

(continued)

TABLE C-3
CHARACTERISTICS OF INDIVIDUAL TROLLEY BUS SYSTEMS

TRANSIT SYSTEM	OPERATING EMPLOYEE EQUIVALENTS										
	TRANSPORTATION			MAINTENANCE					GENERAL ADMINISTRATION		TOTAL
	ADMIN.	REV. VEH. OPER.	SUPPORT	VEH. MAINT. ADMIN.	REV. VEH. INSPECT. & MAINT.	VEH. MAINT. SUPPORT	NON-VEH. MAINT. ADMIN.	NON-VEH. MAINT. SUPPORT	MKTG. & PLANG.	SUPPORT	
San Francisco-MUNI	40	592	64	8	108	43	7	30	8	57	957
Seattle Metro	14	236	21	6	20	11	7	24	20	35	393
Philadelphia-SEPTA	50	134	11	2	91	10	9	36	4	46	394
Dayton Miami Vall.RTA	10	69	1	1	15	5	0	13	5	13	130
Boston-MBTA	4	67	10	8	11	10	1	10	1	16	138
AVERAGE	24	220	21	5	49	16	5	23	8	33	403
STANDARD DEVIATION	18	196	22	3	42	14	4	10	7	17	301

(continued)

SOURCE: UMTA Section 15 data for 1989

TABLE C-3 (continued)

TRANSIT SYSTEM	ANNUAL VEHICLE MILES (THOUS)	ANNUAL REVENUE VEHICLE MILES (THOUS)	REVENUE VEHICLE CAPACITY MILES (THOUS)	ANNUAL VEHICLE HOURS (THOUS)	ANNUAL REVENUE VEHICLE HOURS (THOUS)	ANNUAL PASSENGER MILES (THOUS)	TOTAL MILES PER REV. VEH. MILE	REV. VEH. MILES PER REV. VEH. HOUR (MPH)
San Francisco-MUNI	7622	7320	548979	1026	991	118500	1.04	7.4
Seattle Metro	2880	2745	208219	421	320	36610	1.05	8.6
Philadelphia-SEPTA	1605	1527	103824	185	176	21132	1.05	8.7
Dayton Miami Vall.RTA	1634	1610	119678	130	127	14494	1.02	12.7
Boston-MBTA	747	742	48201	57	57	8454	1.01	13.0
AVERAGE	2897	2789	205780	364	334	39838	1.03	10.1
STANDARD DEVIATION	2458	2354	179126	353	340	40436	0.02	2.3

(continued)

TABLE C-3 (continued)

TRANSIT SYSTEM	VEHICLES OPERATED IN MAX. SERVICE	MAX. VEH. IN AVG. PM PEAK PERIOD	MAX. VEH. IN AVG. BASE PERIOD	PEAK TO BASE RATIO	ACCIDENTS	FATAL-ITIES	INJURIES	GALLONS OF DIESEL FUEL (THOUS)	KILOWATT HOURS (THOUS)
San Francisco-MUNI	262	262	184	1.42	1015	0	287	0	32823
Seattle Metro	106	106	71	1.49	311	0	89	0	14903
Philadelphia-SEPTA	62	60	32	1.88	164	0	139	0	12434
Dayton Miami Vall.RTA	40	40	27	1.48	379	0	142	0	6733
Boston-MBTA	25	24	12	2.00	53	0	19	0	1390
AVERAGE	99	98	65	1.65	384	0	135	0	13657
STANDARD DEVIATION	86	86	63	0.24	335	0	88	0	10666

(continued)

TABLE C-3 (continued)

TRANSIT SYSTEM	TOTAL OPERATING EXPENSES (THOUS)	PERCENT OF OPERATING EXPENSES BY OBJECT CLASS									
		SALARIES AND WAGES		FRINGE BENEFITS	SERVICES	MATERIALS AND SUPPLIES		UTILITIES	CASUALTY & LIABILITY	PURCH TRAN	OTHER
		OPER-ATORS	OTHER			FUEL & LUB	TIRES & OTHER				
San Francisco-MUNI	$39,328	49.4	15.7	28.7	0.1	0.0	3.2	2.6	0.0	0.0	0.4
Seattle Metro	$13,028	47.9	15.0	25.4	0.7	0.1	7.8	3.5	-0.1	0.0	-0.2
Philadelphia-SEPTA	$6,437	41.9	13.8	29.8	0.0	0.0	8.0	12.1	0.0	0.0	-5.7
Dayton Miami Vall.RTA	$5,500	37.2	15.2	29.2	2.6	0.2	7.9	7.7	0.0	0.0	0.1
Boston-MBTA	$8,247	23.3	31.2	37.2	1.5	0.1	6.5	3.3	0.6	0.0	-3.7
AVERAGE	$14,508	39.9	18.2	30.1	1.0	0.1	6.7	5.8	0.1	0.0	-1.8
STANDARD DEVIATION	$12,678	9.4	6.5	3.9	1.0	0.1	1.8	3.6	0.3	0.0	2.4

APPENDIX D

BACKGROUND INFORMATION ON AUTOMATED GUIDEWAY TRANSIT SYSTEMS

TABLE D-1
CHARACTERISTICS OF INDIVIDUAL AUTOMATED GUIDEWAY TRANSIT SYSTEMS

System	Company	Start-Up Date	Site Description	System Configuration	Guideway Elevation	Guideway Length (miles)	Number of Stations	Min. Traveling Unit[4] (cars)	Vehicle Speed (mph) Max	Vehicle Speed (mph) Avg.	Daily Operating Hours
Atlanta Airport	AEG-Westinghouse	1980	Airport	Dual-lane shuttle	Underground	2.27	10	1	27	10	20.5 hrs/day
Busch Gardens (Williamsburg, VA)	AEG-Westinghouse	1975	Theme Park	Single-lane loop	Elevated/At-Grade	1.33	2	1	30	18	12 hrs/day (Apr-Oct)
Chicago O'Hare Airport	Matra	1991	Airport	Pinched-loop	Elevated/At-Grade	5	5	2	50	23	24 hrs/day
DFW Airport AIRTRANS	Vought Corporation	1974	Airport Center	Single-lane Multi-loops	Elevated/At-Grade	13.04	28	1	17	10	24 hrs/day
Denver Airport	AEG-Westinghouse	1993	Airport	Pinched-Loop	Underground	1.85	4	1	32	11	24 hrs/day
Detroit DPM	UTDC	1985	Downtown People Mover	Single-lane	Elevated	2.94	13	1	30	12	89 hrs/wk
Disney World	Walt Disney Company	1971	Recreation Center	Single lane and dual-lane loop	Elevated	14.50	9	6	45	18	18 hrs/day
Duke	Otis Elevator Company	1980	University Medical Center	Single-lane and dual-lane shuttle	Elevated/At-Grade/ Underground	0.56	3	1	28	14	24 hrs/day
Fairlane (Dearborn, MI)	Ford Motor Company	1976	Shopping Center	Single-lane shuttle with bypass	Elevated	0.50	2	1	30	19	12 hrs/day
Houston WEDway	Walt Disney Company	1981	Airport	Single-lane loop	Underground	1.37	5	3	15	6	20.5 hrs/day
Jacksonville DPM	Matra	1989	Downtown People Mover	Dual-lane shuttle	Elevated	1.40	3	1	41	16	13 hrs/day 320 days/yr
Las Vegas McCarran Airport	AEG-Westinghouse	1985	Airport	Dual-lane shuttle	Elevated	0.50	2	1	25	17	24 hrs/day
Las Colinas, TX APT	AEG-Westinghouse	1989	Urban Business Center	Dual-lane shuttle On-demand mode	Elevated	0.74	4	1	30	18	On-demand

System	Company	Start-Up Date	Site Description	System Configuration	Guideway Elevation	Guideway Length (miles)	Number of Stations	Min. Traveling Unit[4] (cars)	Vehicle Speed (mph) Max	Vehicle Speed (mph) Avg.	Daily Operating Hours
Miami Airport	AEG-Westinghouse	1980	Airport	Dual-lane shuttle	Elevated	0.51	2	2	30	10	24 hrs/day
Miami Metromover	AEG-Westinghouse	1985	Downtown People Mover	Dual-lane loop	Elevated	3.98	10	1	27	8	16 hrs/day
Morgantown, WV	The Boeing Company	1975	University	Dual-lane shuttle off-line stations	Elevated/At-Grade	7.87	5	1	30	15	76 hrs/wk
Newark Airport	Von Roll Transport Systems	1994	Airport	Pinched-loop	Elevated	4.40	7	6	28	14	24 hrs/day
Orlando Airport	AEG-Westinghouse	1981	Airport	3 Dual-lane shuttles	Elevated	2.21	6	2	30	9	21.5 hrs/day
Pearlridge, HI	Rohr Industries, Inc.	1978	Shopping Center	Single-lane shuttle	Elevated	0.23	2	4	8	4	69 hrs/wk
Seattle-Tacoma Airport	Westinghouse	1973	Airport	2 Single-lane loops with Shuttle connection	Underground	1.70	8	1	26	9	20 hrs/day
Tampa Airport	Westinghouse	1971	Airport	5 Dual-lane shuttles	Elevated	1.90	12	1	30	9	24 hrs/day
Tampa Airport Parking Garage	The Transportation Group Inc.	1991	Airport Parking Garage	Single-lane loop with pinched-end	Elevated/At-grade	0.51	7	1	12	4	24 hrs/day
U.S. Senate Subway (Washington, DC)	The Transportation Group Inc.	1995	Downtown Buildings	Pinched-loop	Underground	0.66	3	3	14	N/A	N/A

[1] It is measured at 2.5 sq. feet per standee for urban system and 5.0 sq. feet per standee for airport system.

[2] These values are for 6-car train.

[3] These values are for 4-car train.

[4] The minimum traveling unit is the smallest number of vehicles that can travel as an individual unit.

N/A Not Available

TABLE D-2
SERVICE AND EMPLOYEE DATA FOR LABOR INPUTS-AGT SYSTEMS

System	Vehicle-Miles	Equivalent Place-Miles (millions)	Vehicle-Hours	Equivalent Full-Time Employees
Atlanta Airport	818,140	40.9	81,814	61
Busch Gardens	24,210	2.1	1,345	22
Chicago O'Hare Airport	489,984	27.9	21,304	60
Dallas/Fort Worth Airport AIRTRANS	2,817,668	78.9	281,767	146
Denver Airport	964,800	54.0	87,709	N/A
Detroit DPM	423,446	42.3	35,287	122
Disney World	5,760,000	115.2	320,000	64
Duke	92,845	1.7	6,632	15
Fairlane	72,749	1.7	3,829	N/A
Houston WEDway	200,621	2.4	33,437	12
Jacksonville DPM	73,200	6.7	4,575	8
Las Vegas McCarran Airport	228,600	11.9	13,447	11
Las Colinas APT	108,000	4.9	6,000	9
Miami Airport	289,230	15.0	28,923	19
Morgantown	911,857	19.1	60,790	56
Newark Airport	3,701,100	40.7	274,156	N/A
Orlando Airport	288,888	14.7	32,099	15
Pearlridge	11,420	0.2	2,855	13
Seattle-Tacoma Airport	596,200	34.0	66,244	13
Tampa Airport	328,022	16.4	36,447	8
Tampa Airport - Parking Garage	151,200	2.6	37,800	N/A

[1] Equivalent full-time employees are computed on the basis of 2,000 man-hours per year.

[2] Equivalent place miles are computed by multiplying equivalent passenger places per vehicle by the vehicle-miles travelled for each system.

APPENDIX E

METRIC CONVERSION FACTORS

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SI* (MODERN METRIC) CONVERSION FACTORS

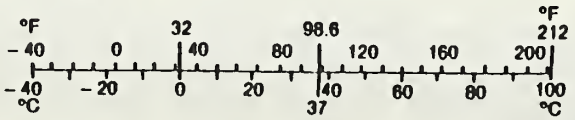
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9	Celcius temperature	°C

NOTE: Volumes greater than 1000 L shall be shown in m^3.

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
TEMPERATURE (exact)				
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F



* SI is the symbol for the International System of Measurement

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